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Inquiry on Federal Water Policy
Research Paper # 16

WATER RESOURCES RESEARCH IN CANADA:
ISSUES AND OPPORTUNITIES

by

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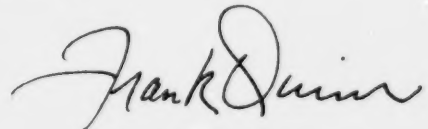
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THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearce, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

A handwritten signature in dark ink, appearing to read "Frank Quinn". The signature is fluid and cursive, with the first name "Frank" being more prominent than the last name "Quinn".

Frank Quinn
Director of Research



Abstract

This report focuses on three objectives: to provide an inventory of water research activities in Canada, to identify future research needs and priorities and to evaluate federal research programs regarding their capacity to respond to changing priorities for water resources research, coordination, and management in Canada. In addressing these objectives, the reported findings include evidence of approximately \$55.8 million being spent on water resources research in Canada in 1983, with the federal government being the dominant participant, providing 73 percent of the funds and expending 51 percent of the funds. This funding level represents an effective 25 percent decrease since 1979.

Extensive discussion is presented on the current structure and organization of water resources research efforts in Canada, problems identified during the information collection effort and recommendations made on possible approaches to improve the situation.

Résumé

Ce rapport poursuit trois objectifs: fournir un inventaire des activités de recherche dans le domaine hydrique au Canada, identifier les besoins et priorités futurs et évaluer les programmes de recherche fédéraux en fonction de leur habilité à répondre aux priorités changeantes dans le domaine de la recherche, de la coordination et de gestion des ressources en eau au Canada.

Les résultats rapportés indiquent qu'environ \$55.8 millions ont été consacrés à la recherche reliée à la ressource eau en 1983. Le gouvernement fédéral a été le principal bailleur de fonds fournissant 73 pourcent de ceux-ci et en dépensant lui-même 51 pourcent. Ce niveau de financement représente une diminution réelle de 25 pourcent par rapport à 1979.

Une discussion détaillée de la structure et de l'organisation actuelles de la recherche reliée à la ressource eau au Canada, des problèmes qui ont été identifiés durant la période de collecte d'information et des recommandations qui sont faites sur les stratégies possibles afin d'améliorer la situation est présentée.

Water resources is a combination of knowledge, understanding and guesswork. Research enlarges the first two.

It only takes one pellet to hit a duck but a shotgun is still used. The role of the research manager is to ensure the gun is pointed in the right direction.

Research is like the sparkplug in an engine. It isn't the sparkplug alone that ensures forward motion but without the sparkplug it is unlikely there will be motion in any direction.

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EXECUTIVE SUMMARY

This report has three objectives. The first is to provide an inventory of water research activities in Canada. Attention focuses upon current arrangements to facilitate water research and upon the levels and nature of research activity. The second is to identify future research needs and priorities. The third is to evaluate federal research programs regarding their capacity to respond to changing priorities for water resources research, coordination, and management in Canada.

About one-quarter of the 301 briefs submitted to the Inquiry on Federal Water Policy explicitly addressed the matter of water resources research. Strong support was expressed from organizations and individuals from across the country for an active and vigorous role in water resources research by the federal government. It repeatedly has been argued that the federal government has roles both as a 'doer' and as 'facilitator' in research, and that ongoing and newly emerging problems require a continued and increased level of research effort.

The federal government has recognized that it does have a role in water resources research. In a 1978 policy statement, the government noted that it had a general mandate for research and identified the activities which it would pursue. In addition, two reviews of water resources research have been conducted. In 1966, the Science Council of Canada organized a detailed review. In 1979, Environment Canada held a second review. This report is based on a third review focused upon 1983. This third review is co-sponsored by the Science Council of Canada and the Inquiry on Federal Water Policy.

With regard to current arrangements for water resources research, the outstanding feature is the large number of participants distributed among the federal and provincial governments, the universities and the private sector. However, the federal government is the dominant participant, and in 1983 it provided 73 percent of the funds and spent 51 percent of the funds for water resources research.

The Inland Waters Directorate of Environment Canada is the lead federal agency. In the 1984-1985 estimates, the Inland Waters Directorate allocated \$22 million or 2-1/2% of the operational budget of Environment Canada to water resources research. In contrast, during 1983 it is estimated that some \$55.8 million was spent on water resources research in Canada.

Despite its dominant role, the federal research effort is not a homogeneous and sharply coordinated set of activities. Within the federal government water research is also pursued by Fisheries and Oceans, Agriculture, Health and Welfare, Energy, Mines and Resources, Transport and the National Research Council. Given the large number of federal line agencies involved in water resources research, a need exists to achieve better coordination. Existing mechanisms for coordination are inadequate either because they are too narrowly focused (NRC Associate Committee on Hydrology), do not have enough of a research focus (Interdepartmental Committee on Water), or do not incorporate enough of the key agencies (Canada Centre for Inland Waters).

Regarding level of effort, Canada generally has a record of providing only modest support for research of most kinds. For example, research and development expenditures in Canada have ranged from .95 to 1.24 of GNP whereas many industrialized countries allocate from 2 to 3 percent. Expressed in 1983 dollars, Canada spent \$29.6 million in 1966, \$75.4 million in 1979, and \$55.8 million in 1983 on water resources research. Thus, between 1979 and 1983 there has been a decrease by 25 percent of funds allocated to water resources research.

The Water Resources Research Support Program through which the federal government provides research funds to universities illustrates the nature of some of the cutbacks. In 1979 the funds for that program were reduced from \$1 million annually to \$250,000 annually. With inflation considered, the actual purchasing power of the \$250,000 has been steadily eroded.

Water quality has received the largest proportion of funding over the years, receiving 30 percent in 1966, 40 percent in 1979, and 53 percent in 1983. Over the same period, there has been a substantial decrease in funds allocated to research dealing with the water cycle, dropping from 47 percent in 1966 to 28 percent in 1983. Throughout, the research effort has been concentrated in central Canada with about 70 percent of the activity located in Ontario and Quebec.

During the public hearings held by the Inquiry on Federal Water Policy, a broad array of research needs was identified. These needs ranged from general concerns with pollution, flooding and water supply, to very specific concerns such as farm-related contaminants into water bodies, peatland water resources, river ice processes, estuary hydrodynamics to freshwater in the boreal plains. In this study, an attempt has been made to identify those needs which are of national significance and therefore of concern to the federal government.

Inventory and monitoring programs exist, but there still is not an adequate descriptive understanding of water resources in Canada. Initiatives in this area to upgrade descriptive understanding must be pursued in consultation and cooperation with the provinces.

Functional knowledge also is poor in many areas. Groundwater deserves more attention. Water diversions or transfers deserve more research, especially regarding their ecological, economic and social impacts. Water quality issues have been and will continue to be important. Wastewater treatment, disposal of toxic wastes and acid rain all require improved understanding. With over 200 communities facing potential flood damages, research is needed to determine adjustment strategies which combine structural and nonstructural responses. Water supply can be a constraint on regional economic development both in urban-centered and rural areas. Attention is needed to develop strategies which combine both supply and demand management methods. Finally, since so many water problems have their causes in adjacent resource complexes, more research should be devoted to integrating water problems with those associated with adjacent land and other resources.

Research needs also can be related to thematic concerns. Efficiency of water use deserves more attention, especially regarding domestic, industrial and agricultural uses. The impacts of water-related development need more research, especially regarding ecological and social aspects not amenable to measurement in monetary terms. Since there usually are risk and uncertainty associated with water management and development decisions, improved methods are needed to identify and explore the trade-offs among benefits, costs and risk elements. And, since management decisions often must accommodate different and conflicting values, more research focused upon conflict resolution would be appropriate.

During the Inquiry hearings, a frequent call was made for more social science research activity. With the cutback in the Water Resources Research Support Program, it has been argued that social scientists should seek funding through the Social Sciences and Humanities Research Council of Canada. However, the prospects for major new initiatives in the social sciences regarding water research are not good when the funding available from the major granting agency is considered. The budget change (net inflation) between 1979-80 and 1983-84 was 57 percent for the Natural Sciences and Engineering Research Council, but only 5 percent for the Social Sciences and Humanities Research Council. Nevertheless, if more social science research were to be developed, in addition to those fields already identified key areas would be policy and planning analysis, and institutional arrangements.

Another type of activity needing support is research which integrates natural science, engineering and social science research. Existing funding organizations do not easily handle research proposals which cut across disciplinary or professional boundaries. A systematic review of policies and procedures used by the major funding agencies to deal with interdisciplinary research is needed, as researchers have expressed considerable frustration and disappointment with current arrangements.

Several findings and conclusions emerge regarding the capacity of federal research programs to respond to changing priorities, coordination and management. Given the number and array of research activity in Canada, more systematic coordination of the water research effort is needed. Formation of a National Water Research Committee would help to minimize duplication of facilities and effort across the country, ensure a balance between national and regional research needs, facilitate communication within the research community, and relate research activity to management needs. Such a Committee should have members from the federal and provincial governments, the universities and the private sector who also could represent the different regions of the country. The Committee would have to be allocated sufficient funds and authority so that it could influence research activity.

A National Water Research Committee would provide a mechanism to develop a national strategy for water research. For the federal perspective to be incorporated into a national strategy, a Federal Committee for Water Resources Research should be established so that federal ideas and efforts in this field can be integrated. At the

moment, such integration and coordination of federal water resources research does not appear to occur in any systematic and ongoing fashion.

Centralization of research has provided scale economies as well as minimum critical masses of investigators, both of which are positive features. At the same time there has been a real cost when regions without one of the centralized research facilities have their water problems ignored or neglected by researchers. To receive the benefits of centralization and still respond to regional research needs, the use of smaller regional research centres linked to the centralized national research institutes offer potential. Atlantic Canada and British Columbia should be priority areas for regional research centres.

To encourage anticipatory or 'blue sky' research, the National Water Research Committee, the national institutes, the regional centres and the Water Resources Research Support Program should allocate a portion of their research budgets to innovative and unrestricted study for which it is recognized from the outset the likelihood of immediate and positive results is low. However, in this way support will be provided for the type of research which might lead to the really major breakthrough. A portion of the research budgets also should be dedicated to supporting research which is interdisciplinary in nature since the traditional funding agencies have difficulty in accommodating such work.

In time of restraint, with few new research scientists being hired and limited mobility for scientists already on staff, attention must be given to training and education. If the federal government is serious about developing expertise in water resources research in Canada, then sufficient resources must be allocated either to hire new staff, facilitate participation in professional meetings or accommodate sabbaticals or other forms of exchanges by federal investigators with their counterparts in other institutions.

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Appreciation is also given to the Inquiry on Federal Water Policy and to the Science Council of Canada, for financial support which allowed the study to be completed.

Chapter 1

INTRODUCTION

1.1 THE ROLE OF THE FEDERAL GOVERNMENT IN WATER RESOURCES RESEARCH

"...there is a very definite need for research which is of national significance, and as such, the federal government must play a dominant role" (Canadian Water Resources Association, 1984, 16). "The Federal government should continue and expand support for water related research" (Spence, 1984, 3). "...The Federal Government could take a leading role in research and education relating to various alternatives of water charges" (American Water Works Association, Ontario Section, 1984, 9.2). "Fund more research on all aspects of water use and ecology" (Alberta Wilderness Association (1984, 15). These four comments present a message which was repeated many times in submissions to the Inquiry on Federal Water Policy. The Federal Government has a role in water resources research as both a "doer" and a "facilitator", and there is need for additional support for water resources research in Canada.

The Federal Government has explicitly recognized that it does have a role in water resources research. In a policy statement on inland waters, Environment Canada (1978a) noted that

The federal government...has a general mandate for conducting research, collecting data and maintaining inventories relating to surface and subsurface water, pollutants and contaminants, fisheries and aquatic ecosystems, atmospheric water, and snow and ice.

In that statement, 16 specific policies were identified. Policy number 14 declared that:

The federal government undertakes water research and technology development programs, provides for additional research and development by contract, and supports through funding, research on water-related problems carried out by non-federal agencies.

Within such a policy framework, Environment Canada (1978a) stressed several considerations. First, research in the natural sciences, social sciences and wastewater treatment technology was viewed as necessary to develop the new knowledge required to formulate and implement water management and pollution abatement programs. Second, co-operative effort within these various fields was essential to ensure better use of Canadian water resources. Third, governmental and non-governmental agencies were seen to have different, but complementary roles in carrying out water resources research.

In a subsequent review of water resources research in the country, Environment Canada (1981a,1) indicated that water resources research had

seven basic goals. Drawn from a study by the U.S. Federal Council for Science and Technology (1966), these included:

- (1) understanding the nature of water, the processes which determine its distribution in nature, its interactions with its environment and the effects of man's activities on the natural processes;
- (2) developing methods for conserving and augmenting the quantity of water available;
- (3) perfecting techniques for controlling water so as to minimize erosion, flood damage and other adverse effects;
- (4) developing methods for managing and controlling pollution so as to protect and improve the quality of the water resource;
- (5) developing and improving procedures for evaluating water resource development and management so as to maximize socio-economic benefits;
- (6) developing techniques for efficient design, construction and operation of engineering works at minimum costs; and,
- (7) developing new methods for efficient collection of the field data necessary for the planning and design of water resource projects.

This discussion reveals that the federal government has recognized and accepted a role for itself in water resources research. This role has received, and continues to receive, strong endorsement from individuals and organizations associated with the water field in Canada. In that context, the federal government has explicitly stated an overall strategy for its involvement in water resources research, and has identified a set of basic goals for such research.

1.2 THE PURPOSE OF THIS STUDY AND ITS RELATIONSHIP TO PREVIOUS STUDIES

This study is the third to examine water resources research in Canada. The first review was started late in 1966 when the Science Council of Canada created a study group to investigate the state of water resources research in Canada. That activity led to a substantive report by Bruce and Maasland (1968) regarding the situation in 1966, as well as to shorter reports by Chevalier (1969) and Sewell, Judy and Ouellet (1969). The Science Council of Canada (1968, 1) concluded that water resources research was "important but....that it has attracted neither adequate attention nor money. Government laboratories do good work but universities lack funds and industrial research is undeveloped".

To strengthen water resources research in Canada, the Science Council (1968, 29-30) offered a series of recommendations. First, more support was needed for subjects which had been neglected but were critical for Canada. The subjects requiring emphasis included particular aspects of water pollution, social and legal aspects of water, ecological impacts from water development, engineering equipment and materials, and some aspects of the water cycle. Second, the Science

Council (1968, 29) argued that

Water resources are so important to Canada and research has been so neglected that the Council recommends an increase in expenditures on research and development in this field at an annual rate of 20 percent from \$8.4 million in 1966 towards a target of \$25 million in 1972-73.

Third, the Council believed that the research capacity in industry should be strengthened, and that this could be achieved by contracting a large proportion of research and data collection to private companies. Fourth, university participation in water research needed encouragement which could be realized through the federal government "assisting the establishment in Canadian universities of a few major research institutes specializing in different fields".

The Science Council devoted an entire section of its report to "the co-ordination of Canadian programs in water resources research". To facilitate better coordination, the Council recommended that the existing National Advisory Committee on Water Resources Research be modified to ensure more equitable representation from government, universities and industry. Furthermore, the Council urged that the National Advisory Committee should be responsible for providing continuing advice to the Minister on the use and application of science to water resources management and development, and for advising on the distribution of research funds to assist university and industrial research.

The second review was initiated by the Inland Waters Directorate of Environment Canada "to determine the current level and direction of research in water resources in Canada, and thus make it possible to identify the appropriate direction for future research efforts" (Lefevre, 1984, 1). This review was conducted in two phases. A questionnaire and personal interviews were used to document the research effort in 1979. Data were collected using the same research categories as the Bruce and Maasland (1968) report to facilitate comparisons. Subsequently, regional workshops were organized to obtain viewpoints from both water managers and research managers in various regions of the country.

Lefevre (1984, 5) reported that a comparison of research effort in 1966 and 1979 showed that total funding had increased to \$52 million in 1979 from \$20 million (1979 dollars, or 8.4 million in 1966 dollars) in 1966. Lefevre (1984, 9) noted that the 250 percent increase in water resources research effort between 1966 and 1979 fell far short of the Bruce and Maasland (1968) recommendation that research support increase at a rate of 20 percent per year. Using the Bruce and Maasland recommendation, the level of support should have increased ninefold by 1979 (Lefevre, 1984, 11). The 250 percent increase over 13 years was considered "significant" but "more indicative of the very low resource level in 1966 than of a sufficient resource commitment in 1979".

In terms of substantive emphasis, this second review found that funding for water quality management and protection advanced from 30 percent of total funding in 1966 to 40 percent in 1979-1980. In contrast, over the same period, support for research on the water cycle dropped from 47 percent to 24 percent. A new focus emerged as well, with the expenditure for environmental management and protection growing to 16 percent of total funding in 1979 whereas it was not even recorded as a separate category in 1966. No specific recommendations were presented in this second review regarding needed work, level of support, nor management of research effort.

This study is the third review, and is co-sponsored by the Science Council of Canada and the Inquiry on Federal Water Policy, each of which provided one-half of the funds for the study. The Science Council's interest in water resources research extends back at least until 1966 when it initiated the first assessment. In its terms of reference, the Inquiry on Federal Water Policy was directed to address four concerns, one of which was to "assess the needs for and nature of additional scientific and research expertise in water management in Canada".

Given the joint interest of the Science Council and the Inquiry in water resources research in Canada, the following terms of reference were developed for this study. The objectives were:

- (1) to update the inventory of water research activities, using the Bruce and Maasland report of 1968 and Environment Canada paper of 1979 (Lefevre report, 1984) as bases, identifying changes in effort among research categories and changes in effort and funding among federal, provincial, university and private sectors.
- (2) to identify future research needs and priorities, in consideration both of current trends and emerging water issues as substantiated by the Inquiry on Federal Water Policy.
- (3) to evaluate federal research programs in terms of their capacity to respond to changing priorities for water resources research, co-ordination and management in Canada.

1.3 WATER RESEARCH AND RELATED SCIENTIFIC ACTIVITY

As in the previous two reviews, it was necessary to decide what was to be included in water resources research and related scientific activity. The Science Council of Canada (1968, 12) had used the following definition: "Research is work undertaken primarily for the advancement of scientific knowledge, with or without specific application in mind. Work in which the element of innovation was lacking, such as in the regular collection of scientific data, was not considered to be research". This same definition was utilized in this study.

It is noteworthy that such a definition does not include items such as data collection, technology transfer, and education and training. Those elements are frequently referred to as "grey" areas of research since they are fundamental elements of a robust research program. This is particularly true for technology transfer since without specific mechanisms for disseminating the research findings, the full utility of the research may never be realized.

In the development of this study, the viewpoint of the Australian Water Resources Council (1982, 31) during a review of the water research in that country, was adopted. In the words of the Council, the ... objectives were not to define the boundaries of this research but, rather, to recommend how it could be more effectively carried out". Thus, considerable efforts were directed toward determining possible approaches to the role of the federal government and how it might best participate in water resources research.

As noted in Section 1.2, the terms of reference directed this review to update the inventory of water research activities in the Bruce and Maasland (1968) and Lefevre (1984) reports. As a result, to facilitate comparisons of research activity and effort it was necessary to use the same major research categories as the earlier studies. These are:

1. Nature of Water
2. Water Cycle
3. Water Supply Augmentation and Conservation
4. Water Quantity Management and Control
5. Water Quality Management and Protection
6. Economic, Social and Economic Aspects
7. Resources Data
8. Engineering Works
9. Environmental Management and Protection.

The ninth category was added in the Lefevre (1984, 4) report to reflect the emergence of environmental management and environmental impact assessment. Specific categories are listed in Appendix 1.

These categories were used to allow comparisons over time. At the same time, it was fully appreciated that many research projects do "not fit neatly" into such a categorization (Lefevre, 1984, 2). In addition, a series of problems mentioned by Dorsey (1984, 7) were recognized from the outset. The categories for classifying research are not always

clearly separable. This issue is compounded in interdisciplinary and policy-oriented studies which consciously involve a mix of these categories and strive to integrate them. The ambiguities in the categories combined with a loose definition of research, raise difficulties in interpreting responses to the survey of research activity and effort. As a small consolation, it also was recognized that any two researchers would be unlikely to agree on definitions for research or appropriate categories for classifying research activity.

1.4 DATA COLLECTION

The study was initiated in mid June 1984, data collection essentially terminated by mid December 1984, and the draft of the report was submitted to the Science Council and the Inquiry on Federal Water Policy in late February 1985.

Several methods were used in this study to assemble data. To update the inventory of research activity and to allow comparisons, a survey was utilized which used the same research categories and questionnaire as Bruce and Maasland (1968). The Bruce/Maasland questionnaire was augmented through the addition of a series of fourteen questions requesting subjective responses to a series of issues. The resulting questionnaire is contained in Appendix 1.

The questionnaires were distributed late in July 1984, and respondents were asked to reply by the middle of September 1984. A subsequent mailing of the questionnaire was carried out in early October to those in universities and private industry thought to be active in water research but who had not responded to the initial mailing. The potential respondents were identified through consultation with professionals in the federal and provincial governments, the universities, and the private sector. Valuable guidance was provided by Dr. Allan Prince, former Director General of the Inland Waters Directorate, who served as a consultant in this phase of the study. In general, a "top-down" approach to questionnaire dispersal was adopted. In requesting information from universities the questionnaire was sent to the Deans of faculties in Canada with the request that they then disperse copies to professors within their faculty. This approach was adopted as a means of assuring a greater likelihood of opportunity for individuals to respond.

Table 1.1 shows the number of questionnaires distributed and the resulting number of responses received. The response rate was encouraging, given that the questionnaire was distributed in mid-summer, a necessity if the data were to be collected in the time-frame demanded by the work schedule of the Inquiry on Federal Water Policy. A further limitation was the length and complexity of the questionnaire, which undoubtedly discouraged some who received it. However, it was felt that since the respondents were all directly associated with water research, the interest and motivation to respond should be present. From some comments received, that assumption was not universally valid.

While the questionnaire was being completed by respondents, data were collected on the mandates and research activities of pertinent federal government departments. A variety of published reports were

Table 1.1 Questionnaire Responses

Research Sector	Number of Questionnaires Distributed	Number of Questionnaire Responses
Federal	13	51 [#]
Provincial	25	20
University	102	61 ⁺
Private Industry	182	64 [*]
Total	322	186

⁺ many responses reflected the views and activities of a group of individuals.

^{*} although a number of responses were received, many consisted simply of statements that no research was being done. On the other hand, a number of companies known to have considerable on-going research, did not complete the questionnaire.

[#] response rate reflects "top down" distribution method discussed in Section 1.4.

used. In addition, Dr. Prince worked in Ottawa to assemble information on behalf of this study. He examined the federal estimates and other records, and abstracted information about level of financial support and person-years devoted to water research.

A workshop was held in Kitchener, Ontario, on November 7 and 8, 1984, to generate further ideas regarding water research. The workshop had several objectives: (1) identification of a national strategy for, and federal role in water resources research, (2) discussion of needed research, (3) consideration of the level of support and rationalization for water resources research, and (4) exploration of alternative approaches for the management of research efforts.

Participants were invited so as to ensure a cross-section of federal, provincial, private sector and university people, as well as to ensure a mix of professional/disciplinary and regional perspectives. Nineteen people participated, coming from six provinces. Participants prepared papers for distribution prior to the workshop itself. The names and professional associations of the workshop participants are included as Appendix II.

During the workshop, participants were given preliminary results of the questionnaire survey. In addition, members of the Inquiry on Federal Water Policy outlined the concerns of the Inquiry and reported on the public hearings which had been held to that point-in-time. The majority of the workshop was devoted to small group discussions in which different combinations of participants met to consider alternative approaches to the objectives identified above. During the final part of the second day, all of the participants met together to explore the various issues identified during the small group discussions.

Other data sources also were used within the development of this study. The staff of the Inquiry forwarded copies of submissions from the public hearings which were judged to have suggestions pertinent to water research. Informal interviews were held in person, and by telephone. These interviews ranged from discussions with Dr. Lefevre concerning the second study on water research in Canada, to individuals in federal research institutes and provincial organizations, the private sector, and universities. Letters were sent to request information regarding the state of water research in selected countries. Finally, other studies of water research were sought and examined. The overall intent was to ensure that a range of cross-checking data sources was employed. While gaps and weaknesses still exist, it is felt that the above procedure was realistic and defensible in the time available for the study.

1.5 REPORT ORGANIZATION

The following chapters are organized to address the three questions this study was asked to consider. With regard to research effort, Chapter 2 describes the current arrangements for water resources research in Canada, identifies some of the mechanisms developed to facilitate coordination and communication of research activities, identifies a number of constraints which influence arrangements for research, presents information about levels of funding and nature of

effort in research, and finally, provides two case studies regarding the funding patterns for two organizations. While the second chapter presents basic information about research activity in Canada, the third chapter presents the reactions and views of the research community relative to some of the issues and concerns which constrain and inhibit research efforts. Thus, Chapters 2 and 3 should be viewed as complementary, both addressing different aspects of research effort. These two chapters provide the context for subsequent chapters dealing with research issues and research strategies.

Chapter 4 provides an overview of substantive water research issues which are judged to be of national significance and therefore pertinent to the federal role in water research. Chapter 5 outlines an overall strategy for water resources research, while Chapter 6 presents conclusions.

Chapter 2

NATURE OF THE RESEARCH EFFORT

2.1 CURRENT ARRANGEMENTS FOR WATER RESOURCES RESEARCH IN CANADA

Water resources research is conducted in Canada within the federal government, the provincial governments, universities, and the private sector. Within the federal government, Rodgers (1984, 1) has noted that "water research takes place in a dozen or so agencies" and in addition that "the variety of agencies funding water research do not, in general, have common objectives notwithstanding important alliances on several issues. It would be misleading to consider water research of all agencies as a homogeneous effort".

Before reviewing the current arrangements for water resources research, it is appropriate to identify several significant developments since the Bruce and Maasland report in 1968. Two major federal inland waters research establishments were created. The Canada Centre for Inland Waters, the headquarters for the National Water Research Institute, was established at Burlington, and the Freshwater Institute was established at Winnipeg. Furthermore, the National Hydrology Research Institute, now based in Ottawa, currently has new headquarters under construction in Saskatoon. In addition, the International Hydrological Decade (1970-1979) and the Canada/USA Great Lakes Water Quality Agreement (1972;1978) provided powerful stimuli for research activity, even if a considerable portion of it was on a one-time occurrence. Finally, creation of Departments of the Environment at federal and provincial levels consolidated much of the environmental activity into single organizations, and provided a base for substantial investments in water quality research during the 1970's and 1980's. Against this background, the present arrangements for research in the federal and provincial governments, universities and the private sector can be reviewed.

2.1.1 The Federal Government

2.1.1.1 Environment Canada

The Inland Waters Directorate (IWD) of Environment Canada is the lead federal agency for water management. In the 1984/85 estimates, water resources research by IWD included \$22 million and 212 person-years. The \$22 million represents 2-1/2 percent of the total operational budget (\$886,879,000) for Environment Canada in 1984/85.

IWD is responsible for gathering and disseminating water quantity and quality data. The Water Resources Branch operates a comprehensive network of streamflow gauging stations and water level stations on lakes. The Water Quality Branch regularly monitors the aquatic environment. For example, at the Canada Centre for Inland Waters, the laboratories conduct an average of 1,000 tests each day for different aspects of water quality. The Water Planning and Management Branch is responsible for flood damage reduction and forecasting water demand. It has been conducting research on the economic impact of designating floodplains as well as on modelling industrial, agricultural and

residential water demand.

An important focus for water resources research in IWD is the Canada Centre for Inland Waters. It has been characterized as "a place, not an agency", which is home to several organizations concerned with freshwater resources as well as serving as a base for hydrographers, oceanographers and land use specialists. In 1983/84, it employed about 559 scientists and support staff, and had a budget of \$ 19.2 million in salary, \$11.2 million in operating and \$2.8 million in capital expenditures.

The Canada Centre for Inland Waters (CCIW) was established in 1966. The purpose was to consolidate in one place the water research activities occurring in the federal Departments of Energy, Mines and Resources; Fisheries and Forestry; and National Health and Welfare. The water components of these three departments became parts of the Department of the Environment formed in 1970 (Environment Canada, 1975, 220). Thus, CCIW can be viewed as a pioneering effort to integrate, coordinate and rationalize water resources research effort at the federal level.

The CCIW was established at Burlington, at the western end of Lake Ontario. The intent was to create a "national centre of expertise in water resources research, including anti-pollution studies" (Environment Canada, 1975, 220). The research and data collection efforts at CCIW are used as input for both federal and provincial programs of water management and development. Furthermore, technical advice is provided during the formulation and implementation of federal water policies and programs.

The National Water Research Institute (NWRI), a part of IWD, has its headquarters at CCIW in Burlington but also has regional centres in Winnipeg and Vancouver. It employs approximately 300 people, most of whom are in Burlington. In contrast, the usual staff complement at the NWRI Branch in Winnipeg is 4 scientists and 5 technicians (Environment Canada, 1982, 149), and this small group, working in cooperation with research scientists at the Freshwater Institute in Winnipeg, is responsible for research pertinent to all three Prairie provinces as well as the Northwest Territories. The Branch based in Winnipeg is viewed by NWRI as fulfilling "the need for local expertise in problem areas specifically regional in nature" (Environment Canada, 1982, 149).

The NWRI conducts water research with reference to chemical, physical, biological and environmental problems of lakes, rivers and reservoirs as well as urban and coastal regions. The Institute is generally perceived to be interested in problems of water quality, and this is reflected in the 5 research divisions within NWRI: (1) aquatic ecology, (2) aquatic physics and systems, (3) hydraulics, (4) analytical methods, and (5) environmental contaminants.

As indicated, the National Water Research Institute is primarily responsible for water quality research although it should be recognized that it has a major program in environmental hydraulics and another in

geophysical fluid dynamics. In contrast, the National Hydrology Research Institute is mainly responsible for research on water quantity although it also conducts work focused on groundwater quality. Specifically, the NWRI specializes in research related to (1) underground waters, (2) snow and ice, and (3) surface water (Environment Canada, 1983, 20).

The Inland Waters Directorate is not the only agency within Environment Canada conducting water-related research.

Also based at CCIW in Burlington is the Wastewater Technology Centre which is responsible for conceiving, developing and providing new wastewater treatment technologies and sludge disposal techniques both for municipalities and industries. Its research is separated into three groups: (1) biological processes, (2) physical/chemical processes, and (3) residue management. The actual research and development is conducted within laboratories and pilot plants at CCIW and in mobile pilot plants which can be transported to industrial sites across the country.

Early in 1984, the Atmospheric Environment Service received Treasury Board approval for phase 1 of the "Canadian Climate Program". The first phase has two priorities: the production of monthly and seasonal climate predictions, and research on CO₂-related climate change and its socio-economic impacts. The socio-economic research will be carried out through contracts, primarily with universities. The funds available for the socio-economic research are \$135,000 in 1984-1985, \$290,000 in 1984-1986, and \$310,000 in 1986-1987 for a total of \$735,000. The first round of contracts will focus upon two themes both of which are directly relevant to water management: (1) water resources of the Great Lakes - St. Lawrence system, and (2) food and agriculture in various regions across Canada. Contract money to be allocated in 1985 and 1986 will include research relevant to water resources elsewhere in Canada, forestry, the North, and energy development. In the words of the Director General of the Canadian Climate Program (1984), "Through CCP-sponsored research, we hope to draw on the full range of expertise in both the social and physical sciences needed for this interdisciplinary research, and thereby help to build crucial interdisciplinary capability for the conduct of climate impact studies".

Other Environment Canada organizations also conduct related research. The Canadian Wildlife Service monitors and identifies contaminant levels in wildlife, and thereby gauges the presence and buildup of toxic substances in the aquatic ecosystem. The Lands Directorate maps land use, monitors and assesses land-use changes, and studies terrestrial ecosystem processes. In that manner, its research activity contributes directly to water research programs dealing with acid rain, soil erosion, environmental impact, and land use conflicts.

2.1.1.2 Fisheries and Oceans

In the 1984/85 estimates, the federal Department of Fisheries and Oceans allocated \$79,170,000 and 1,127 person-years to fisheries research, or about 11 percent of its total budget on fisheries

research. A significant proportion of that research effort is water-related since the quality of aquatic ecosystems is critical for survival and enhancement of freshwater fish as well as anadromous species such as salmon.

A major concentration of research effort by Fisheries and Oceans is at the Freshwater Institute at Winnipeg. At the Institute, research is conducted on fish habitat and limnology, emphasizing processes and mechanisms of biological production and decomposition in lake systems (Ayles, 1984, 1). Research has covered such aspects as hydroelectric reservoirs, acidification, radionuclide and heavy metal pollution, and toxic chemicals. At the Canada Centre for Inland Waters in Burlington, Fisheries and Oceans operates the Great Lakes Biolimnology Laboratory. Three programs there address environmental toxicology, surveillance, and ecosystem studies, and collectively explore the effects of human activity on the well-being of the Great Lakes fishery and the overall freshwater ecosystem, including the impact of acid rain and other contaminants.

2.1.1.3 Agriculture

In the 1984/85 estimates, the federal Department of Agriculture designated a research budget of \$22,637,000 for natural resources (land, water, energy, environmental quality). Of that total, \$2,517,000 and 47 person-years were allocated to research related to water. In its submission to the Inquiry, the Department of Agriculture identified four activity areas pertinent to water. First were surveys and monitoring, especially agri-food water use and forecasting. Second, was basic and applied research conducted within the Research Branch. The Research Branch uses a consultative system involving two committees. The Canadian Agricultural Research Council and the Canadian Agricultural Services Coordinating Committee are used to establish research priorities with provincial governments, universities and the private sector. Third, a development program is used to assemble and assess packages of programs which facilitate technology and product transfer. Fourth, activity is focussed upon the regulation and registration of pesticides.

2.1.1.4 National Health and Welfare

The Environmental Health Directorate of the Health Protection Branch, National Health and Welfare, has been in existence for 14 years. The purpose of the Directorate is to protect Canadians from health hazards associated with natural and man-made environments. The present staff of the Directorate is 270 and has an annual budget of approximately 13 million dollars.

In its submission to the Inquiry, National Health and Welfare indicated that it has two distinct roles with respect to water. A national-scale role involves research on, and development of, guidelines for drinking water and recreational water quality. In these respects, the Department undertakes national surveys of drinking water quality for priority contaminants and facilitates cooperative projects among the provinces, such as training of waterworks operators. A "provincial" type of role is undertaken through the provision of environmental health

services in areas under federal jurisdiction such as national parks, reservations, defense bases, and on common transportation carriers, as well as for all communities north of the 60th parallel.

From the departmental estimates, it was difficult to identify the allocation of funds or person-years to water-related research. It was indicated, however, that the research effort allocated to water problems is extremely modest.

2.1.1.5 National Research Council - Associate Committee on Hydrology

The Associate Committee on Hydrology is one of a number of NRC Associate Committees which was established primarily to address problems of national significance which "can be solved by the application of scientific expertise or additional coordinated and focussed research" (Environment Canada, 1981a, 2). Based in the National Research Council, the Associate Committee encompasses more than federal interests. Its 29 members are drawn from researchers and managers from federal and provincial governments, universities and technical societies (Associate Committee on Hydrology, 1984, 1).

The Associate Committee on Hydrology has four functions. First, it facilitates contact among research and operational agencies and individuals in Canada, working in hydrology. Second, it disseminates knowledge and information through organizing symposia and workshops, organizing national lecture tours, as well as publishing newsletters and other reports. Third, it formulates research priorities for hydrology. Beginning in 1976, and every three years after, the Associate Committee has defined aspects of hydrology deserving greater research and experimental development. Fourth, it promotes international hydrologic development by serving as the Canadian National Committee for the UNESCO International Association of Hydrological Sciences.

2.1.1.6 Other Federal Agencies

A variety of other federal agencies conducts water-related research or provides funding for such research. They are mentioned briefly here to complete the picture of the large number of federal agencies involved in water research. The Department of Energy, Mines and Resources conducts or facilitates research related to groundwater. Such work ranges from surveys and monitoring to the exploration of technologies to utilize the energy available in thermal groundwater supplies. The Department of Transport conducts research as it relates to freshwater transportation and navigation. Significant effort has been devoted to developing and testing technologies to extend the length of the shipping season in the Great Lakes - St. Lawrence system. The Department of Indian and Northern Affairs, responsible for that part of Canada north of 60 latitude, has been involved in a variety of water research activities, ranging from work to support comprehensive basin studies for the Yukon and MacKenzie Rivers, to research related to possible water pollution associated with resource development projects in the North.

2.1.2 Federal Granting Agencies

In Section 2.1.1, the focus was upon the mandates and responsibilities of federal line agencies and other organizations related to water research. Such organizations both conduct research in-house as well as contract out such work to the private sector and universities through the Department of Supply and Services or through various research support programs. However, through the traditional granting agencies, the federal government also makes substantial funds available to the university research community. In this section, the characteristics of these funding agencies are described with regard to a comment that "'pure researchers' in water should compete with 'pure researchers' in any other field for pure research funding from the general funding sources" (Cardy, 1984, 2). The three major funding agencies and their level of support are shown below.

Funding Agencies and Levels of Support

	<u>1983 - 1984</u>	<u>1984 - 1985</u>
Natural Sciences and Engineering Research Council of Canada	\$ 282,100,000	\$ 291,300,000
Medical Research Council	\$ 137,312,984	\$ 156,900,000
Social Sciences and Humanities Research Council of Canada	\$ 54,400,000	\$ 62,800,000

2.1.2.1 Natural Sciences and Engineering Research Council of Canada

The functions of NSERC are to promote and assist research in the natural sciences and engineering other than the health sciences. Fields which are supported include agriculture, biology, biotechnology, chemistry, engineering, environmental toxicology, forestry, geography (physical), geology, oceans, physics, and interdisciplinary. Support is given to academic staff members of Canadian universities. Work is funded under six major activities: research grants (operating and strategic), research infrastructure grants, university-industry programs, developmental grants, general research support, and research manpower awards.

During 1983-1984, NSERC supported over 17,000 individuals through its programs of grants and scholarships and launched its University-Industry program to encourage interaction between university researchers and Canadian industry. Research grants totalling \$160.1 million were awarded, including 5,933 discipline research grants. Scholarships and fellowships totalled \$40.2 million and were distributed to 1,494 undergraduate and 2,422 graduate students. A comparison of NSERC's 1983-1984 budget of \$282.1 million with that of 1979-1980 (\$120.7 million) reveals a 135 percent increase in current dollars, or when inflation is considered, a real increase of 57 percent (NSERC, 1984).

2.1.2.2 Medical Research Council

The MRC supports research in the field of health sciences. Since some diseases are communicated or nourished by water, some funds from the MRC could support water-related research. During 1983-1984, the MRC allocated \$137.3 million to support health sciences research, of which \$83 million was distributed under "grants in aid for general research".

2.1.2.3 Social Sciences and Humanities Research Council

SSHRC was established in June of 1977 and began operating in April 1978. It took over programs in the humanities and social sciences previously handled by the Canada Council. Its mandate is to promote and assist research and scholarship in the social sciences and humanities. SSHRC (1984, 22) noted that its budget increase from 1978-1979 (\$30.4 million) to 1983-1984 (\$54.4 million) represented a growth of 79 percent. However, if inflation is taken into account and the comparison is made in constant 1978 dollars, the increase was from \$30.4 million in 1978-1979 to \$31.9 in 1983-1984, a real increase of only 5 percent.

2.1.2.4 Interdisciplinary Research

NSERC, MRC and SSHRC consider applications for major interdisciplinary research projects which overlap the mandates of the granting agencies (NSERC, 1984a, 3). In such situations, investigators are directed, prior to submitting a proposal, to contact the agency judged to have the major interest in the research. The Councils then endeavour through discussion to ensure that arrangements are made for appropriate assessment.

Interdisciplinary proposals also may be considered by an agency if a proposal overlaps several disciplines within that agency's mandate. To illustrate, NSERC (1984a, 15) has an Interdisciplinary Grant Selection Committee to cover situations when formal consultation between two or more other grant selection committees is not adequate to ensure a thorough evaluation. The Interdisciplinary Committee involves a small core membership with advisors drawn from other grant selection committees, or from outside sources, depending upon the circumstances. Thus, in theory, a mechanism does exist for the review of interdisciplinary research proposals, although most of the appraisers are selected from a pool of reviewers who were originally selected for their expertise in a specific discipline.

Nevertheless, many researchers responding to the survey conducted as part of this review expressed doubt as to the commitment of the major funding Councils to interdisciplinary research. Slivitsky (1984, 10) has concisely summarized some of these concerns:

...a number of specific research projects which cross the boundaries of chemistry, earth science and biology end up with the committee for interdisciplinary research which has yet to find proper ways to completely fulfill its role. The same could be said for problems which fall between the "engineering" committees and the "pure science" committees: too fundamental for the first -- too applied for the second.

The issue of integration becomes even more demanding and difficult when it involves bringing together the social and natural sciences as compared to integrating research among the natural sciences alone. This issue is critical when it is appreciated that policy-oriented research usually must address problems which cut across the natural and social sciences.

2.1.2.5 Environment Canada, Inland Waters Directorate, Water Resources Research Support Program

In addition to applying to NSERC, MRC and SSHRC, university-based investigators may also apply to research programs administered by line agencies. The Water Resources Research Support Program (WRRSP) of the Inland Waters Directorate is the main research program for water resources research.

The WRRSP is one element of Environment Canada's overall Science Subvention Program which was designed to help Environment Canada realize its objectives through facilitating development of ideas generated by non-government scientists. The program supports research with "a significant component of concept development and exploration of novel approaches". Disciplinary or interdisciplinary research involving the physical, biological, engineering and social sciences may receive support. A primary concern is "to establish an effective dialogue between non-government scientific institutions and the Department in areas of mutual interest and concern" (Environment Canada, 1984).

The level of funding for the WRRSP program has been reduced substantially over the past decade. For 1973-1974, the WRRSP provided grants totalling \$1,146,660. Of that total, \$276,660 was given to support 44 individual projects at 24 universities (Environment Canada, 1975, 224). The balance of \$870,000 provided support to 6 Canadian universities for continuing development of interdisciplinary water resources research centres (Westwater Research Centre, University of British Columbia, \$180,000; Division of Hydrology, University of Saskatchewan, \$140,000; Agassiz Centre for Water Studies, University of Manitoba, \$155,000; Wastewater Treatment Centre, McMaster University, \$125,000; Institute of Environmental Sciences and Engineering, University of Toronto, \$140,000; Le Centre de Recherches sur l'Eau, Laval, \$130,000).

By 1976-1977, the WRRSP provided \$1,000,000 which was shared among 21 universities to study problems in nine priority areas identified by Environment Canada (1976). During 1978-1979, the WRRSP again allocated \$1,000,000, to 24 universities for research in seven priority areas specified by Environment Canada (1978, 1).

However, in August 1978 the Government of Canada announced that as part of general restraint, the WRRSP would be reduced from \$1,000,000 to \$250,000, effective in April 1979. Thus, by 1982-1983, the \$250,000 was distributed to only 13 universities (Environment Canada, 1983, 24). By 1984-1985, this same level of funding was directed by Environment Canada (1984) towards "a limited number of specific high priority areas" and it was expected that "not more than 10 to 12 proposals will be funded".

In response to this cutback, researchers attempted to persuade NSERC to identify water as a candidate field for support under its Strategic Grants program. However, Slivitsky (1984, 11) has reported that "NSERC has replied to such requests that not enough related proposals have appeared in the open area over the last few years to justify such an initiative". This situation led the Inland Waters Directorate in January 1984 to contact investigators to encourage them to submit water-oriented proposals to NSERC. The hope was that if a substantial increase in water research proposals were received, then NSERC would decide to include water in the Strategic Grants program. However, this pattern of funding in the WRRSP provides confirmation for Rodger's (1984, 3) observation that "support for water research in universities has decreased considerably in the past 7 to 10 years". This reduction has generated concern by many individuals and groups making submissions to the Inquiry. The Canadian Water Resources Association (1984, 16) expressed concern about "what appears to be a reduction in real federal dollars made available for water resources research" and along with other groups, urged that this trend be reversed.

Other concerns also have been expressed. In the words of the Saskatchewan Research Council (1984, 6-7), "the subvention program is not effective because the same group of people get the money and which is too small an amount for effective research". In addition, the Saskatchewan Research Council (1984, 6) queried why the subvention program was available only to university scientists. It argued that the program should be open to investigators employed in a range of institutions which would include governmental and private organizations.

2.1.3 Provincial Governments

While the federal government has many agencies active in conducting or supporting water research, the provincial governments also provide support for water-related work. Given their responsibility for management of water within provincial boundaries, provinces have devoted funds for monitoring of water flow and testing of water quality. The provinces also have given funds for background studies for comprehensive river basin plans, many of which have been joint, co-operative efforts with the federal government.

Many of the provinces also fund research councils such as the Alberta Research Council or Saskatchewan Research Council which devote some of their research effort to water problems specific to that province.

2.1.4 Universities

Environment Canada (1975, 224) has stated that "since universities are the major source of research manpower, strong programs in water research at these centres are prerequisites for performance in the other research sectors". However, research activity at the university level is not a homogeneous effort, but instead can be pursued in many ways".

Multidisciplinary or interdisciplinary research centres which focus upon water research can be established. Examples are the now defunct Agassiz Centre at the University of Manitoba, and the Westwater Centre at the University of British Columbia, entering its 15th year of operation in 1985. Alternatively, multidisciplinary institutes or programs may exist which address water as one of several resource management concerns. Examples here are the Masters of Natural Resource Management program at Simon Fraser University and the Institute of Environmental Studies at the University of Toronto. A third alternative is a group research program focussed upon a selected aspect of water, such as the Division of Hydrology at the University of Saskatchewan, the Water Conservation Program at the University of Waterloo or the Watershed Ecosystem program at Trent University.

Other approaches include small groups of scientists which form to undertake a specific study, and then dissolve themselves until another situation arises in which that combination of expertise is needed, or individuals or small teams can undertake projects either through research grants or contracts. This category normally accounts for the greatest activity both regarding manpower and allocated funds.

University water researchers obtain nearly all of their research funds from outside their universities, usually from government line agencies, granting agencies, or the private sector. In a national strategy for research, therefore, it is important that consideration be given to encouraging the different types of research activity ranging from the large interdisciplinary centre or institute to the individual scholar.

A noteworthy exception with respect to funding sources is the Centre for Water Resources Studies at the Technical University of Nova Scotia which receives a grant of about \$20,000 from the university to assist the administration of the Centre. The Centre was established in 1981 to encourage coordinated research programs in water resources.

2.1.5 The Private Sector

Research activity in the private sector is the most difficult category to inventory because of the diffuse, and confidential nature, of much of the work. Industrial and manufacturing firms often conduct inhouse research to make their water use more efficient or to reduce wastes to be discharged into receiving waters. However, because this

work is usually undertaken to enhance the profitability of the firm, the results are not often published in the normal research journals. Furthermore, since the time for such work usually involves individuals doing a number of tasks in parallel, it is difficult to inventory the effort.

Associations representing private sector interests also may fund work. For example, during the autumn of 1984 the Canadian Electrical Association invited proposals to conduct research to determine the extent to which environmental predictions made during environmental assessments of selected hydroelectric projects in Canada were confirmed during post-development experience. The CEA was providing a budget of \$100,000 and stipulated that the work was to be completed within one year. Such research involves activity that is pertinent to water research, and yet determining what proportion should be categorized as water research is difficult. The twin difficulties of identifying research activity in the private sector and estimating which proportion is "water-related" ensure that estimates regarding water research in the private sector can only be of a "ball park" variety.

Consulting firms conduct research for government agencies and the private sector. The work can range from multi-million construction projects in Canada or overseas, to two or three-day projects for municipalities or small firms. Due to the large number of consulting firms, it is difficult to inventory their effort.

A source of funding for water resources research is the private foundation. Since 1975, the Devonian Group of Charitable Foundations, based in Calgary, has had available capital, plus income, of \$71 million. In conjunction with the Canada West Foundation, the Devonian Group supported a study of the water resources of interior western and northwestern Canada from 1979 to 1982. Based in Toronto, the Donner Canadian Foundation (1984) has identified "oceans and inland waters" as one of five fields for which it will provide support. Donner indicates that "prime consideration is given to applications which do not fall under the terms of reference of other agencies active in the field, and to experimental ventures for which seed money is not always available". Two water-related projects were funded in 1983. The North American Wildlife Foundation received \$225,000 for research on waterfowl and wetland ecology at the Delta Waterfowl Research Station near Portage la Prairie in Manitoba. The Rawson Academy of Aquatic Science was given \$124,400 to conduct a major review of water resources in Canada.

2.2 COORDINATION AND COMMUNICATION OF RESEARCH ACTIVITY

Given the wide array of organizations and individuals involved in water research, it would seem reasonable to assume that overall effectiveness would be improved if the effort were coordinated and if the participants maintained contact with one another. A number of mechanisms for coordination and communication exist. Those which are in use are briefly reviewed below.

2.2.1 Coordination Mechanisms

2.2.1.1 Interdepartmental Committee on Water

The Interdepartmental Committee on Water (ICW) was created to facilitate interdepartmental considerations and approval of "all federal water programs" (Environment Canada, 1983, 3). It usually meets about three times a year, and in the year ending on March 31, 1983 it had 26 members representing a total of 20 departments and agencies with an interest in water matters. Subcommittees and Working groups are established as required. During 1982-83, 4 subcommittees existed: (1) Canada-US, Great Lakes Quality Agreement, (2) water quality, (3) floods, and (4) to prepare responses to IJC reports. Two working groups were concerned with containerized water export and preparation of a federal water strategy paper. No subcommittee or working group explicitly addressed research on a comprehensive basis.

Even if research were explicitly and systematically addressed by the federal Interdepartmental Committee on Water (ICW), an evaluation completed by Environment Canada (1981, 16-17) raises serious questions about the adequacy of such a mechanism. In the review it was concluded that while the Inland Waters Directorate approached the consultative function of the committee in a serious manner and used it as a vehicle for interdepartmental review of its own programs, "other agencies are more likely to make decisions and let ICW know as an information item later". Furthermore, the ICW was viewed as a headquarters institution which did not appear to strengthen regional coordination of federal activities.

2.2.1.2 National Research Council - Associate Committee on Hydrology

The Associate Committee on Hydrology exists to foster contact between research and operational agencies and individual scientists, to disseminate knowledge and information, and to formulate research priorities. Within its narrow concern of hydrology, it undoubtedly does a reasonable job since it incorporates people from federal and provincial agencies as well as universities and industry. However, it does not, and can not, serve as a coordinating group for the broad mix of water research issues which range from quantity to quality and from health to agricultural concerns.

2.2.1.3 Canada Centre for Inland Waters

CCIW was established to consolidate in one place, the water research activities of three federal departments. That was a forward move in integrating federal water research efforts, but by itself has not been sufficient to coordinate water research at the federal level since many line agencies are not represented at Burlington, nor at the regional offices of NWRI.

2.2.2 Data Management Systems

Data and information reference systems can serve as a vehicle to keep investigators informed of the results of research activity across the country. The federal government operates a number of such data management systems (Environment Canada, 1983, 25-26).

WATDOC provides direct, nationwide access through computer terminals to an inventory which lists water-related articles and reports. WATDOC is publicly available through an on-line storage and retrieval system. NAQUADAT, the national water quality monitoring program's data bank, stores and retrieves chemical, physical, bacteriological, biological and hydrometric data pertinent to water quality. STAR is a system for limnological data generated from monitoring cruises on the Great Lakes. WATENIS is a water effluent national information system. It provides an inventory of industrial and municipal water pollution sources as well as information regarding water effluent regulations and guidelines. MUNDAT, a data base for municipal waterworks and wastewater systems, was developed in cooperation with the provincial governments and the Federation of Associations on the Canadian Environment (FACE). HYDAT has been developed to store and retrieve data on streamflow, water levels and sediment transport collected through federal-provincial Water Quantity Agreements.

From these examples, it can be seen that the federal government has taken considerable initiative in developing data management systems which should be useful to researchers in federal and provincial governments, universities and the private sector. As with all such data management systems, a key is to ensure that potential users are aware of the systems and their characteristics, and that the systems are accessible to users. The worth of such systems cannot be assured by their existence. Consequently, an assessment of these data management systems would be appropriate.

2.2.3 Journals

Refereed articles in journals represent a source which researchers traditionally rely upon to keep abreast of work in their field. Several water-oriented journals exist in Canada. The Canadian Water Resources Journal (*Revue Canadienne des Ressources en Eau*) is published quarterly by the Canadian Water Resources Association, a national non-governmental organization now in its 38th year. The first issue of the Journal appeared in October 1976, published with financial assistance from Environment Canada. The journal gives preference to papers focussing on information and policy aspects. Papers are published in both English and French.

The Water Pollution Research Journal of Canada (WPRJC) is sponsored by the Canadian National Committee of the International Association of Water Pollution Research and Control. Papers focus on all aspects of water pollution research. Before 1984, the WPRJC was published by the University of Toronto. One issue was published each year with a focus on the engineering aspects of pollution. A small Editorial Board was dominated by university engineering departments based in southern Ontario. In 1984, the Chief Editor became an individual at the National

Water Research Institute, and the Editorial Board was expanded to include scientists from government agencies and universities across the country. By 1986 it is intended that the journal will be published quarterly.

The Canadian Journal of Civil Engineering is published bimonthly by the Canadian Society for Civil Engineering. Research papers relevant to water resources are included within categories of hydrotechnical engineering and environmental and sanitary engineering. Supporting contributions to the costs of publication are made by the National Research Council of Canada.

Eau du Québec is a journal published by the Association Quebecoise des Techniques de l'Eau which was founded in 1962. It is published quarterly. All papers are in French, with the focus upon water and wastewater treatment in Quebec. The journal is oriented to researchers and practitioners in the public, university and private sectors.

Thus, in Canada there exist a number of journals through which research findings can be disseminated. However, Canadian journals do not always ensure that good communication occurs between the researchers and the managers, or users. As Cardy (1984) observed, research findings may not be used if they are published in "a very technical or high-powered research journal which practitioners don't read. (This is common because researchers are rated by their peers not by the application of their research, so they aim to publish in the most prestigious journals, not the most widely read)".

Another consideration is that regardless of the number of Canadian journals, researchers also will publish their research in international journals. This may be done for one or more of several reasons. As Rodgers (1984, 7) commented:

1. Staff look to international recognition for promotion criteria.
2. Canadian journals, where they exist, lack the stature of international publications.

Slivitzky (1984, 8-9) expressed a similar concern when noting that "the growing tendency to publish outside of Canada and in very specialized journals does not tend to bring the results to the attention of the users. Most of these journals, especially the ones recognized by the peers, are unknown or unread by the professionals in operating agencies".

2.2.4 Conferences and Workshops

A variety of conferences and workshops are held every year, ranging from annual and regional conferences of the Canadian Water Resources Association to "one-shot" events such as the Government of Ontario's "Futures in Water Conference" in June 1984 or the Rawson Academy's symposium on "Canada's Waters: The State of the Resource" to be held during late May 1985. In addition, organizations such as the NRC - Associate Committee on Hydrology and the Canadian Society of Civil Engineers organize technical meetings to facilitate exchange of research results.

Dissatisfaction appears to be growing with regard to large conferences in which presentations are restricted to 10 or 15 minutes and in which "there is barely time for a question following most presentations" (Cardy, 1984). In this context, enthusiasm is expressed for more workshops, smaller group gatherings, less reading of papers, and more discussion, debate and exchange of ideas. In this regard, the federal government has taken some positive initiatives. For example, in May 1982 the Inland Waters Directorate convened a 3-day workshop on "Social Impact Assessment and the Flood Damage Reduction Program" in which federal government and other experts met for an intensive discussion ranging over program effectiveness and research requirements. A similar format was used in November 1982 in a technical workshop focussing on Streamflow Forecasting.

2.3 CONSTRAINTS AND REALITY

2.3.1 Fragmentation of Research Effort

Because water has an influence on so many human activities, it is not surprising that a number of federal line agencies allocate some of their research effort to water. Environment Canada, as the lead agency, addresses both quantity and quality issues. Fisheries and Oceans is concerned with water-related problems which have implications for the fishery. National Health and Welfare addresses health and safety aspects, especially drinking water and waste disposal. Agriculture examines the role of water in the production of food. The ministry of Transport focusses upon transportation on inland waters, particularly significant in the Great Lakes - St. Lawrence River system. The outcome is a dispersion of research effort amongst a variety of federal line agencies which have associated institutes and laboratories scattered across the nation.

Fragmentation of research effort is exacerbated further when it is appreciated that the provinces have a major responsibility for water management within their jurisdictions, and therefore also invest money and human resources in water-related research through line departments responsible for natural resources and the environment. In addition, many of the provinces have research institutes or centers which devote some of their attention to water problems. When the provincial and federal research effort is viewed in conjunction with water-related research activity in universities and the private sector (industry, consultants, foundations), it becomes apparent that a major management issue is how to coordinate and integrate research activity which is dispersed across many organizations located across the country.

At the moment, although various attempts at coordination have been made, there appears to be scope to make more effective use of the water resources research funding and talent in the country (Section 2.2). As a senior federal official responsible for managing water research commented, "Somebody has to be accountable for specific objectives and be given reasonable control over the resources to achieve those objectives. As it stands at the moment, the control is widely separated".

2.3.2 Regulatory Role

In addition to being fragmented among a variety of line agencies, the federal water research programs often must function to support the regulatory or operational responsibilities of line agencies. This situation is particularly significant for the lead water agency, Environment Canada. About 25 percent of the research and scientific service functions of NWRI have, through commitment in Treasury Board submissions, been directed to Great Lakes Water Quality problems.

Given the important regulatory mandate of such federal agencies as Environment Canada, the research managers encounter significant constraints when conceiving and designing research. In other words, the range of choice of research projects is restricted substantially by the regulatory mandate of the organization. Pressure exists for water research in such agencies to be short-term and mission-oriented rather than long-term and basic in nature. Such pressure in itself is not necessarily inappropriate given the needs of the line agency, but it does contribute to a situation in which relatively low priority is given to anticipatory research focussed upon the problems of the future, rather than those of the present.

2.3.3 Centralization

As in many fields of research, the cost of equipment for regular monitoring and/or experimental testing is rising steadily. Within the federal government in the last five years, this consideration has been an important influence in a trend toward centralization of research activity. Not only has centralization been pursued to realize economies of scale for expensive and sophisticated equipment, it also has been viewed as desirable by creating concentrations of researchers who can interact with, and stimulate, one another.

These real advantages of centralization - scale economies and synergistic effects from concentrated groups of investigators - must be balanced against some negative considerations. Acquisition of expensive and sophisticated equipment can lead to a bias towards research dependent upon such equipment and neglect of other important research, not requiring the same level of infrastructure. Furthermore, the centralized groups of scientists may find it increasingly difficult to respond to the needs of managers spread across the country. Indeed, a tendency can occur for an emphasis in research upon problems in the region in which the centralized research facility is located, and neglect of problems in other regions.

The concern about centralization was expressed clearly in a submission by the Honourable G.R. McMahon (1984, 19), Minister of Community and Cultural Affairs for Prince Edward Island. In his words,

"In hydrology, the province maintains contact with the National Hydrology Research Institute of Environment Canada. However, with a significant portion of the agency's work force devoted to other federal agencies, little groundwater research has been carried out in the Atlantic Region in the last several years.

The planned transfer of this agency from Ottawa to Saskatoon in 1985-86 is further reason for concern. The feasibility of this agency conducting field research in the region becomes even more reduced".

These types of problems reinforce the need for a mechanism to plan and coordinate research activity at a national level.

2.3.4 Regional Issues

Water problems and issues vary from region to region across the country. The priority water issues in Atlantic Canada are not always identical to those of the Prairies, while issues in British Columbia often are different from those in Quebec. Regional differences in natural landscape, climate, settlement patterns and economic activity combine to generate a mix of problems. While some issues such as acid rain are significant for a number of regions, others are unique to specific regions or areas. This situation was mentioned frequently in the submissions to the Inquiry and by the experts consulted during this investigation of water research activity in Canada. It also was noted in the earlier reviews by Bruce and Maasland (1968) and Lefevre (1984).

The existence of different regional water issues and problems generates tension with respect to the trend towards centralization of research effort in federal laboratories and line agencies. As centralization is pursued, an increasing concern arises that the ability to respond to regional issues may be reduced. A major management problem therefore is to accommodate the presence of different regional problems while realizing economies of scale and benefits of interaction among scientists resulting from centralization of research activity.

2.3.5 Varying Perspectives

A variety of legitimate perspectives exist regarding research activity. Federal researchers often define their research work with reference to the mandates of their organizations. Provincial investigators take a similar perspective regarding their mandates. In the private sector, research is usually pursued to improve the efficiency of industrial processes or to develop new products or services which can be marketed on a commercial basis. Within the universities, research of a fundamental or pure nature may be pursued with funding from organizations such as NSERC or SSHRC, or may be done on a contract basis for government or the private sector.

In brief, the motivations for research may vary from sector to sector. Even if each group plans and coordinates its research activity in the interest of enhancing effectiveness within its sector, there is no assurance that an effective national strategy of research will emerge in the present situation, as there is no group responsible for considering the national perspective. In this context, a federal and national perspective are not synonymous. Nevertheless, the federal government should have a major role in helping to formulate and implement a coherent national strategy for water resources research.

2.4 CURRENT FUNDING LEVELS

2.4.1 Some Comments on Difficulties in Quantification

Although simple in concept, the quantification of the dollars associated with water resources research is extremely difficult. These difficulties arise for a number of reasons worth explaining briefly since frequent reference will be made in subsequent sections to the need to employ assumptions in the quantification of research efforts. The difficulties include:

(i) What is water research? The underlining emphasizes that the predominant concern is on water as the primary focus of the research. The difficulty in identifying water research is whether water is the primary focus, or whether, for example, it is insect research.

(ii) What is water research? The underlining emphasizes that the activity must involve research and not, for example, routine data collection. There is no control on how adequately this criterion was used during completion of the questionnaire by individual respondents. The concerns do not end here, however, in that information from some funding agencies only included individual project titles; it was necessary therefore to guess whether or not projects being funded qualify as research.

As well, indirect and overhead costs are difficult to quantify and to determine to what extent they should be included in research expenditures. These include administration and common services such as library, major common-user facilities and housing.

(iii) What is the category of research? To indicate the emphasis in direction of ongoing research, both within this study and for the previous studies (Bruce and Maasland (1969) and Lefeuve (1984)), a series of categories of research have been identified. To allow for the characterization of trends that may be occurring with time, the same categories of research as used with the Lefeuve study have been employed. Regardless, individual researchers frequently expressed considerable difficulty in assigning a particular category to their work with a common response that several categories were all applicable. Where more than a single category was noted in a questionnaire response, the approach adopted in the assignments to allow summations of the activity levels in the individual categories was simply to assume an equal distribution of effort within the categories specified.

(iv) To what degree is the "double-counting" of dollars a problem? This concern arises because several organizations may be reporting the same contract. For example, both the funding agency and the consultant doing the actual work, may list the same project. Obviously such a situation would overestimate the expenditures on research. The extent of any double-counting in the tables to follow is not felt to be appreciable, since considerable efforts were extended to eliminate this problem whenever sufficient information was provided to trace the dollar flows.

(v) Substantive responses from consultants were extremely minimal. This determination was very disappointing since it is only from the consultants themselves that an accurate assessment can be obtained of research funds obtained from other than federal agencies and selected provincial agencies (i.e. those which responded or publish annual reports). Since consultants claim they want to do more research, it is unfortunate to see how few deemed it worthwhile to indicate their interests and concerns through completion of the questionnaire.

(vi) Scale adjustments in research efforts were necessary because responses were not received summarizing all activities. The majority of the scaling undertaken was with NSERC operating grants — a total of 1.5 million dollars was reported in the questionnaire responses, whereas 3.27 million dollars for water resources research were identified as being funded, from the NSERC file records. Presuming that the reported university research funds from other sources (e.g. municipal, provincial, and industry) represented the same ratio as with the NSERC operating grants, these other sources of research revenue to the universities were also scaled by the ratio of $3.27/1.5 = 2.18$. Exceptions to the scaling were followed when reports were available on total fundings from a particular agency or organization (e.g. the Ontario Ministry of the Environment and the Donner Foundation); for these funds, the research expenditures were accepted as published.

(vii) Budget responses from universities did not include such dollar values as those of salary costs of professors, graduate student scholarships and overhead costs on many projects (e.g. those funded by NSERC).

The intent of the preceding is to indicate the types of difficulty of assignment of research dollars that are presented in the section to follow. The resulting tabulations represent the combination of analyses of questionnaire returns, contacts with individuals and agencies, examination of financial reports, etc. The data base is admittedly incomplete. Anyone in the field could, undoubtedly, identify specific omissions or incorrect characterizations. Refinements may always be made but within reasonable time and budget limitations and the approximations indicated above, the findings are felt to be fairly representative of current research efforts in Canada.

Table 2.1 Research Source and Expenditure Dollars
By Sectors of Research Community, 1983

Research Sector	Source		Expenditures	
	(\$ in 000's)	(% of Total)	(\$ in 000's)	(% of Total)
Federal	40852.1	73.2	28190.1	50.5
Provincial	8985.7	16.1	7099.7	12.7
University	1447.8	2.6	14897.0	26.7
Industrial	2390.2	4.3	5632.4	10.1
Municipal	930.2	1.7	----	----
Foreign	305.8	.5	----	----
Other	907.2	1.6	----	----
Totals	55819.		55819.	

Table 2.2 Research Funds for Water Resources,
Over Time

Year	(Values in \$000's)	
	Research Funds in Given Year	Research Funds in 1983 Dollars*
1966 (Bruce/Maasland)	8389.	29640.
1979	52000.	75400.
1983		55820.

*using the consumer price index to update funding levels

Table 2.3 Changes With Time, of Percent of
Total Funding By Source

<u>Funding Sector</u>	Year		
	<u>1966</u>	<u>1979</u>	<u>1983</u>
Federal	69.3	56.0	73.2
Provincial	17.3	29.6	16.1
University	10.1	2.7	2.6
Industry	3.3	11.6	4.3
Municipal	--	--	1.7
Foreign	--	--	.5
Other	--	--	1.6

Note - all values expressed in percents of total

Table 2.4 Changes With Time of Percent of
Total Funding by Expenditure

<u>Research Sector</u>	Year		
	<u>1966</u>	<u>1979</u>	<u>1983</u>
Federal	44.4	41.1	50.5
Provincial	21.0	25.0	12.7
University	19.4	18.8	26.7
Industry	14.0	15.1	10.1

Note - all values expressed in percents of total

2.4.2 Source and Expenditure Levels of Research Monies

As an overall summary, the research dollars in relation to various research sectors are listed in Table 2.1 - the first column of values indicates the dollars provided by the research sector as the source of revenue, whereas the second column of values indicates the research expenditures by the respective research sector. As indicated by the last row of numbers, a total of 55.8 million dollars (1983) is expended on water-related research in Canada. The research funding is derived from a number of sources but the majority is from a very few.

An indication of the time-history of funding levels for water research is provided in Table 2.2 (the consumers price index was used for the updating). The indicated values present updated values to 1983 for the Bruce and Maasland and Lefevre studies. There is a substantial increase over 1966 funding but not at the levels which were recommended in the Bruce-Maasland report. In addition, a significant decrease in research funding in terms of 1983 dollars, is noted, from the 1979 study findings.

An examination of the funding levels by source as they have changed over time is interesting, with the various percentiles as indicated in Table 2.3. It would be inappropriate to attempt to draw too many conclusions from the figures but certainly some general trends are noteworthy:

- (i) budgets available from universities as a source of research money have essentially disappeared;
- (ii) industry contributions as a source of research money have increased; and,
- (iii) the federal sector has continued to provide the greatest portion of the research funds available.

The changes with time of percent of total fundings as measured by expenditure, are indicated in Table 2.4. Given the uncertainty in the data, it is difficult to discern any significant trends although it appears there is an increasing role being filled by the federal sector while a decreasing role is being filled by the provincial sector.

Indications of the subject emphases of the funds provided by the various sources are summarized in Table 2.5. The sub-categories as included in Table 2.5 (and those to follow) have been chosen so as to coincide with those categories used in the previous studies.

As summary comments overall:

- (i) support by federal research dollars is spread over all the sub-categories but 56 percent of the total is within the 500 series dealing fairly specifically with water quality concerns.

Classified by Source (000\$)

Table 2.5 Research

Code	Sub-categories	Classified by Source (000\$)					
		Fed.	Prov.	Univ.	Indy.	Foreign	Total
101	Properties of Water.....	151.8	17.9	10.0	1.9	2.3	192.7
102	Aqueous Solutions and Suspensions.....	---	---	---	---	---	0.0
201	Water Cycle, General.....	830.5	59.8	23.4	43.9	6.0	980.5
202	Precipitation.....	252.0	---	---	---	---	252.0
203	Snow and Ice.....	2707.1	434.3	53.3	431.8	4.9	3650.5
204	Evaporation and Transpiration.....	45.6	4.4	2.3	0.2	---	55.5
205	Streamflow.....	440.9	336.3	16.2	2.6	3.7	813.8
206	Groundwater.....	2379.1	829.7	325.7	31.7	41.6	4074.4
207	Water in Soils.....	---	7.0	---	---	---	7.0
208	Lakes.....	1877.2	80.5	4.1	40.6	1.1	2015.2
209	Water and Plants.....	49.7	10.4	4.9	1.1	---	71.1
210	Erosion and Sedimentation.....	1156.6	458.0	45.4	64.3	10.1	1812.8
211	Chemical Processes.....	1022.2	302.4	16.7	2.6	3.8	1362.2
212	Estuarine Problems.....	215.0	46.9	20.0	2.8	4.0	304.0
301	Saline Water Conversion.....	125.7	---	---	45.7	---	171.4
302	Water Yield Improvement.....	175.1	97.4	22.1	3.5	5.0	322.2
303	Use of Water of Impaired Quality.....	65.9	17.8	9.1	1.4	2.0	128.9
304	Conservation in Domestic Use.....	---	---	---	---	---	0.0
305	Conservation in Industry.....	432.2	158.3	59.2	6.3	9.1	700.1
306	Conservation in Agriculture.....	71.3	229.4	---	209.0	---	509.7
307	Weather Modification.....	369.6	93.6	15.0	2.4	3.4	497.0
401	Control of Water on the Land.....	86.8	48.1	10.9	276.0	2.5	433.8
402	Groundwater Management.....	289.8	6.3	1.1	0.9	---	300.3
403	Effects of Man's Activities on Water.....	---	---	---	---	---	---
501	Identification of Pollutants.....	3010.2	530.1	104.3	21.1	12.4	3727.6
502	Sources and Fate of Pollution.....	7996.7	808.3	49.9	145.1	11.4	9084.7
503	Effects of Pollution.....	8832.6	2481.0	257.3	252.4	57.9	12229.9
504	Water Treatment Processes.....	2336.4	246.3	17.8	68.6	2.9	2683.0
505	Ultimate Disposal of Wastes.....	100.5	303.9	21.0	7.1	3.7	450.6
506	Water Treatment.....	---	191.4	---	---	---	191.4
507	Water Quality Control.....	710.3	205.5	62.9	7.8	7.6	1024.0
601	Planning.....	300.8	66.1	74.7	304.6	3.5	774.2
602	Evaluation Processes.....	523.9	46.6	23.8	192.3	93.7	940.5
603	Cost Allocation, Sharing, Pricing.....	---	---	---	---	---	0.0
604	Water Requirements.....	170.1	4.5	2.3	0.6	---	180.4
605	Water Law.....	---	---	---	---	---	0.0
606	Institutional Aspects.....	90.4	12.3	4.5	1.1	1.1	266.0
607	Sociological and Psychological Aspects.....	121.8	---	---	---	---	121.8
608	Ecologic Impact of Water Development.....	327.4	5.6	1.9	7.5	---	497.7
701	Network Design.....	161.3	32.9	35.6	1.6	2.3	338.4
702	Data Acquisition.....	1742.4	309.1	15.3	160.6	2.5	2240.6
703	Evaluation, Processing and Publication.....	40.0	10.3	---	6.9	---	57.1
801	Specifications and Design.....	1287.4	438.1	73.7	44.1	6.3	1876.0
802	Materials.....	---	---	---	---	---	0.0
803	Operations.....	---	---	---	---	---	0.0
901	Environmental Health and Protection.....	355.7	35.4	63.5	---	---	460.1
902	Environmental Health and Protection.....	---	---	---	---	---	1837.4
903	Environmental Health and Protection.....	---	---	---	---	---	305.8
904	Environmental Health and Protection.....	---	---	---	---	---	55819.0

- (ii) support from provincial agencies is slightly less in terms of percent of total to water quality in the 500 series (53%), with considerable emphasis (29%) on the 200 series.

In a context similar to Table 2.5, the funds expended by the various research sectors within the sub-categories are summarized in Table 2.6. As apparent from the indicated dashes, certain types of research are not being pursued within some of the research sectors.

Summary information of the changes in emphasis of the research, as quantified by percentages within each of the 100's of the sub-categories, is provided in Table 2.7. Trends toward an increasing emphasis on water quality are apparent.

The expenditures on water resources research amounted to \$56 million. While this expenditure may seem quite large, it amounts to only approximately \$2.25 per Canadian citizen. To put this in a better comparison with other expenditures, expenditures on other concerns (in accord with Statistics Canada records) include:

Expenses per Family (1983 \$)

water	\$ 78.8
electricity	\$ 452.5
telephone	\$ 354.9
laundry	\$ 102.5
house insurance	\$ 103.3
contents insurance	\$ 55.1
health insurance	\$ 225.0
cigarettes	\$ 366.1
vehicle insurance	\$ 382.0

Thus, while the expenditures on research may seem quite large, there exists a great need for more water research in Canada and the expenditures on research in comparison with other expenditures being made, are very small. Canadians are becoming more aware of the importance of water resources and will be looking to their governments for sound stewardship.

2.4.3 Distribution of Research Effort in Canada

The numbers of research projects classified by sector or agency of performance are provided in Table 2.8. It is readily apparent that the majority of research projects are undertaken within the federal sector, followed by universities, the provinces and lastly, the private sector.

2.4.4 Changes of Emphasis in Research Effort

Summarized in Table 2.9 are the percentages of the total water resources research expenditures within the different categories of research, as quantified over time. Some changes in emphasis are readily apparent whereby a decreased emphasis on the water cycle has occurred with an increased emphasis on quality management and protection. The remainder of the categories have remained essentially unchanged.

Table 2.6 Research Funds Classified by Expenditures (000\$)

Code	Sub-categories	Fed.	Prov.	Univ.	Private	Operate	Capital	Total
101	Properties of Water.....	46.3	---	146.5	---	174.7	18.0	192.7
102	Aqueous Solutions and Suspensions.....	0.0	---	---	---	0.0	---	0.0
201	Water Cycle, General.....	660.0	---	274.3	46.3	944.0	36.5	980.5
202	Precipitation.....	190.9	27.4	33.7	---	252.0	---	252.0
203	Snow and Ice.....	2313.4	630.3	325.0	381.9	3396.3	254.0	3650.3
204	Evaporation and Transpiration.....	21.7	---	33.8	---	47.0	8.5	55.5
205	Streamflow.....	162.5	382.6	236.7	32.0	811.1	2.7	813.8
206	Groundwater.....	264.9	1073.1	2672.3	64.1	3973.8	100.6	4074.4
207	Water in Soils.....	---	4.9	---	22.1	27.0	---	27.0
208	Lakes.....	1677.4	65.7	60.4	211.7	1957.7	57.5	2015.2
209	Water and Plants.....	---	---	71.1	---	71.1	---	71.1
210	Erosion and Sedimentation.....	698.8	356.6	663.1	94.3	1778.3	34.5	1812.8
211	Chemical Processes.....	772.5	346.3	243.4	---	1325.0	37.2	1362.2
212	Estuarine Problems.....	---	---	258.3	45.7	301.0	3.0	304.0
301	Saline Water Conversion.....	---	---	---	171.4	130.0	41.4	171.4
302	Water Yield Improvement.....	---	---	---	---	0.0	---	0.0
303	Use of Water of Impaired Quality.....	---	---	322.2	---	316.2	6.0	322.2
304	Conservation in Domestic Use.....	---	---	128.9	---	127.9	1.0	128.9
305	Conservation in Industry.....	---	---	---	---	0.0	---	0.0
306	Conservation in Agriculture.....	---	---	581.8	118.3	685.3	14.8	700.1
307	Weather Modification.....	---	509.7	0.0	---	477.7	32.0	509.7
401	Control of Water on the Land.....	186.3	19.4	218.3	72.9	469.0	28.0	497.0
402	Groundwater Management.....	---	---	159.5	274.3	283.8	150.0	433.8
403	Effects of Man's Activities on Water.....	277.5	---	22.8	---	287.3	13.0	300.3
501	Identification of Pollutants.....	2587.6	156.6	933.3	50.2	3384.3	343.0	3727.6
502	Sources and Fate of Pollution.....	7354.2	647.7	761.1	321.7	8664.3	420.4	9084.7
503	Effects of Pollution.....	6418.1	1823.9	3857.1	130.7	16229.8	600.1	12229.9
504	Waste Treatment Processes.....	2194.2	197.1	96.3	195.4	2673.0	10.0	2683.0
505	Ultimate Disposal of Wastes.....	---	142.4	239.7	68.6	443.6	7.0	450.6
506	Water Treatment.....	385.1	105.7	---	85.7	180.7	10.7	191.4
507	Water Quality Control.....	---	114.3	490.7	33.8	1011.0	13.0	1024.0
601	Planning.....	---	---	398.7	375.5	727.3	46.9	774.2
602	Evaluation Processes.....	---	1.1	385.8	553.6	939.5	1.0	940.5
603	Cost Allocation, Sharing, Pricing.....	---	---	---	---	0.0	---	0.0
604	Water Requirements.....	146.3	---	34.1	---	180.4	---	180.4
605	Water Law.....	---	---	0.0	---	0.0	---	0.0
606	Institutional Aspects.....	---	---	112.8	153.1	266.0	---	266.0
607	Sociological and Psychological Aspects.....	---	---	73.0	48.8	121.8	---	121.8
608	Ecologic Impact of Water Development.....	304.0	---	34.8	158.9	489.7	8.0	497.7
701	Network Design.....	28.6	94.9	215.0	---	335.3	3.1	338.4
702	Data Acquisition.....	1176.1	400.0	144.4	520.1	1950.7	289.9	2240.6
703	Evaluation, Processing and Publication.....	---	---	---	57.1	56.1	1.0	57.1
801	Specifications and Design.....	49.1	---	482.6	1344.3	1845.0	31.0	1876.0
802	Materials.....	---	---	---	---	0.0	---	0.0
803	Operations.....	---	---	---	---	0.0	---	0.0
900	Environmental Health and Protection.....	274.7	---	185.6	---	459.8	0.5	460.3
	Total.....	28190.1	7099.7	14897.0	5632.4	53174.8	2644.3	55819.1

Table 2.7 Comparison Between 1966, 1979 and 1983 Research
Funds Classified by Source

Funding Sector		Category									Total
		100	200	300	400	500	600	700	800	900	
Federal	1966	87	9700	1350	800	5235	800	1250	1335	0	20530
	1979	450	9920	710	1030	21050	1320	1680	2335	3785	42280
	1983	152	10976	870	746	22987	1534	1944	1287	356	40852
Provincial	1966	0	3335	145	245	1030	130	220	30	0	5135
	1979	230	5050	60	2235	6540	260	1045	420	6500	22330
	1983	18	2570	503	148	4767	135	352	438	35	8986
Industry	1966	60	90	15	0	2480	0	45	320	0	3000
	1979	0	1740	30	30	2525	115	160	2550	1625	8770
	1983	2	622	266	279	502.1	506	169	44	0	2390
University	1966	0	710	15	0	160	60	0	30	0	970
	1979	0	915	45	0	390	90	410	115	60	2015
	1983	10	512	90	27	513	107	51	74	64	1448
Total	1966	145	13820	1520	1045	8905	985	1510	1710	0	29640
	1979	680	17620	840	3290	30510	1785	3290	5425	11960	75400
	1983	193	15399	1832	1231	29391	2781	2636	1876	460.1	55819

Table 2.8 Number of Research Projects Classified by Agency of Performance

Code	Sub-categories	Agency of Performance					Total
		Fed.	Pr.	Mun.	Private	Univ.	
101	Properties of Water.....	2	---	---	---	3	5
102	Aqueous Solutions and Suspensions.....	---	---	---	---	---	---
201	Water Cycle, General.....	19	---	---	1	7	27
202	Precipitation.....	1	---	---	---	---	1
203	Snow and Ice.....	13	7	---	2	8	30
204	Evaporation and Transpiration.....	4	---	---	---	1	5
205	Streamflow.....	3	4	---	---	6	13
206	Groundwater.....	8	9	---	---	30	47
207	Water in Soils.....	---	1	---	1	---	2
208	Lakes.....	12	2	---	---	2	16
209	Water and Plants.....	---	---	---	---	3	3
210	Erosion and Sedimentation.....	12	3	---	1	5	21
211	Chemical Processes.....	1	4	---	---	4	9
212	Estuarine Problems.....	1	---	---	1	4	6
301	Saline Water Conversion.....	---	---	---	2	---	2
302	Water Yield Improvement.....	---	---	---	---	---	---
303	Use of Water of Impaired Quality.....	---	---	---	---	---	---
304	Conservation in Domestic Use.....	---	---	---	---	1	1
305	Conservation in Industry.....	---	---	---	---	4	4
306	Conservation in Agriculture.....	---	---	---	---	6	6
307	Weather Modification.....	1	---	---	---	---	1
401	Control of Water on the Land.....	1	1	---	1	2	5
402	Groundwater Management.....	---	1	---	1	4	6
403	Effects of Man's Activities on Water.....	4	---	---	---	---	4
501	Identification of Pollutants.....	15	4	---	---	9	28
502	Sources and Fate of Pollution.....	54	12	---	1	14	81
503	Effects of Pollution.....	44	6	---	---	19	69
504	Waste Treatment Processes.....	---	5	---	2	2	9
505	Ultimate Disposal of Wastes.....	---	3	---	---	3	6
506	Water Treatment.....	---	3	---	---	3	6
507	Water Quality Control.....	3	1	---	---	10	14
601	Planning.....	---	---	---	2	10	12
602	Evaluation Processes.....	---	2	---	2	3	7
603	Cost Allocation, Sharing, Pricing.....	---	---	---	---	---	---
604	Water Requirements.....	1	---	---	---	2	3
605	Water Law.....	---	---	---	---	---	---
606	Institutional Aspects.....	---	---	---	---	4	4
607	Sociological and Psychological Aspects.....	---	---	---	---	---	---
608	Ecologic Impact of Water Development.....	2	---	---	1	1	4
701	Network Design.....	---	2	---	---	4	6
702	Data Acquisition.....	11	1	---	1	4	17
703	Evaluation, Processing and Publication.....	---	---	---	1	1	2
801	Specifications and Design.....	1	---	---	3	9	13
802	Materials.....	---	---	---	---	---	---
803	Operations.....	---	---	---	---	---	---
900	Environmental Health and Protection.....	5	---	---	---	---	5
Total.....		218	71	---	23	188	500

Note - In some situations only reported research dollars were provided, but no indication of the number of projects being undertaken. As a consequence, there are projects which are not included in the above table.

Table 2.9 Percentage of Effort Within Different
Categories of Research

		(all values in percent of total)		
<u>Category</u>		<u>1966</u>	<u>1979</u>	<u>1983</u>
100	Nature of Water	.5	.5	.3
200	Water Cycle	47.	24.	27.6
300	Supply Augmentation and Conservation	5.	1.	3.3
400	Quantity Management and Control	4.	4.5	2.2
500	Quality Management and Protection	30.	40.5	52.7
600	Economic, Social and Institutional Aspects	3.	2.	5.0
700	Resources Data	5.	4.5	4.7
800	Engineering Works	5.5	7.	3.4
900	Environmental Management and Protection	na	16.	.8

Note - na category not included in 1966 study

2.4.5 Geographical Distribution of Research Effort Within Canada

Indications of the geographical distribution of the water research effort in Canada are provided in Tables 2.10 and 2.11 where the number of water research projects being carried out in each province (and Ottawa) and the research expenditures being made within each province (and Ottawa), respectively, are provided. It is readily apparent that the majority of research efforts are currently being carried out in Ontario. On the other hand, the emphasis on more regionally-specific aspects of water resources are being pursued in specific locales, viz the classes of 300 (Supply Augmentation and Conservation) and 400 (Quantity Management and Control).

It is to be noted there are projects which could not be assigned due to a lack of information available to the study - e.g., only reported research dollars expended by an agency but not the geographical location at which the expenditures are made. Thus, the numbers reported in Table 2.10 are definitely on the low side.

2.4.6 NSERC Funding Levels by Discipline

NSERC continues to be the major source of funding for water resources research at universities. As estimated within this study, 31 percent of the total funding of water resources research at universities was obtained from general NSERC grants. In addition, 16 percent of total funding of water resources research at universities was obtained from the Strategic Grants program of NSERC. Thus, NSERC alone provides 47 percent of the funding for water resources research at universities in Canada.

The departmental distribution of the NSERC monies is indicated in Table 2.12 for Grants and in Table 2.13 for Strategic Grants. The tabulated information indicates how the Strategic Grant research dollars are being directed in larger grants, in comparison with the general NSERC grants (the Strategic Grants being approximately $43400/18700 = 2.3$ times as large). The intent in the Strategic Grants program to direct larger grants toward priority areas is obviously being pursued.

2.4.7 Funding Through the Department of Supply and Services

Funding agencies, in combination with Department of Supply and Services (DSS), represent a significant component of research directed in particular to the private or industry sector. An indication of the funding role of DSS is provided by the data summarized in Table 2.14.

Several remarks may be made:

- (1) DSS funding by the unsolicited proposal route provides a valuable opportunity for supporting innovative work, since the incentive at least in part, encourages individuals and organizations to be innovative in their unsolicited proposals;

Table 2.10 Number of Water Research Projects Performed in Each Province (and Ottawa)

Code	Sub-categories	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	P.E.I.	Mfld.	Total
101	Properties of Water.....	--	--	--	--	3	2	--	--	--	5
102	Aqueous Solutions and Suspensions.....	--	--	--	--	--	--	--	--	--	--
201	Water Cycle, General.....	1	--	--	2	4	18	--	1	1	27
202	Precipitation.....	--	--	--	--	1	--	--	--	--	1
203	Snow and Ice.....	2	3	1	--	10	9	--	5	--	30
204	Evaporation and Transpiration.....	--	--	--	--	1	4	--	--	--	5
205	Streamflow.....	--	4	--	1	7	1	--	--	--	13
206	Groundwater.....	--	2	6	--	30	7	--	1	1	47
207	Water in Soils.....	--	--	--	--	2	--	--	--	--	2
208	Lakes.....	1	1	--	--	13	--	1	--	--	16
209	Water and Plants.....	--	--	--	1	2	--	--	--	--	3
210	Erosion and Sedimentation.....	4	2	--	1	10	2	--	--	--	21
211	Chemical Processes.....	--	--	1	1	3	--	1	3	--	9
212	Estuarine Problems.....	1	--	--	--	1	--	--	4	--	6
301	Saline Water Conversion.....	2	--	--	--	--	--	--	--	--	2
302	Water Yield Improvement.....	--	--	--	--	--	--	--	--	--	--
303	Use of Water of Impaired Quality.....	--	--	--	1	--	--	--	--	--	1
304	Conservation in Domestic Use.....	--	--	--	--	4	--	--	--	--	4
305	Conservation in Industry.....	--	--	--	--	--	--	--	--	--	--
306	Conservation in Agriculture.....	--	--	3	--	--	3	--	--	--	6
307	Weather Modification.....	--	--	1	--	--	--	--	--	--	1
401	Control of Water on the Land.....	--	1	--	1	2	1	--	--	--	5
402	Groundwater Management.....	--	1	--	--	--	--	5	--	--	6
403	Effects of Man's Activities on Water.....	--	--	--	3	1	--	--	--	--	4
501	Identification of Pollutants.....	--	2	--	3	22	--	--	1	--	28
502	Sources and Fate of Pollution.....	--	3	--	10	57	9	--	1	1	81
503	Effects of Pollution.....	2	1	--	9	57	--	--	--	--	69
504	Waste Treatment Processes.....	1	--	--	--	8	--	--	--	--	9
505	Ultimate Disposal of Wastes.....	1	3	1	--	1	--	--	--	--	6
506	Water Treatment.....	1	1	1	--	3	--	--	5	--	5
507	Water Quality Control.....	1	--	--	9	4	--	--	--	--	14
601	Planning.....	3	--	--	4	5	--	--	--	--	12
602	Evaluation Processes.....	--	1	--	1	5	--	--	--	--	7
603	Cost Allocation, Sharing, Pricing.....	--	--	--	--	--	--	--	--	--	--
604	Water Requirements.....	--	--	--	--	2	1	--	--	--	3
605	Water Law.....	--	--	--	--	--	--	--	--	--	--
606	Institutional Aspects.....	--	--	--	--	4	--	--	--	--	4
607	Sociological and Psychological Aspects.....	--	--	--	--	--	--	--	--	--	--
608	Ecologic Impact of Water Development.....	--	1	--	1	1	--	--	1	--	4
701	Network Design.....	--	--	--	--	6	--	--	--	--	6
702	Data Acquisition.....	--	--	1	--	9	6	--	--	--	16
703	Evaluation, Processing and Publication.....	--	--	--	1	1	--	--	--	--	2
801	Specifications and Design.....	2	1	--	1	5	--	3	--	1	13
802	Materials.....	--	--	--	--	--	--	--	--	--	--
803	Operations.....	--	--	--	--	--	--	--	--	--	--
900	Environmental Health and Protection.....	--	--	--	--	5	--	--	--	--	5
	Total.....	21	27	12	52	291	61	13	11	8	498

Note - in some situations only reported research dollars were provided, but no indication of the number of projects being undertaken. As a consequence, there are projects which are not included in the above table.

Table 2.11 Research Expenditures in Each Province (percentages)

Code	Sub-categories	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	N.S.	P.E.I.	Nfld.
101	Properties of Water.....	--	--	--	--	58	42	--	--	--	--
102	Aqueous Solutions and Suspensions.....	--	--	--	--	--	--	--	--	--	--
201	Water Cycle, General.....	3	--	--	17	10	67	3	--	--	--
202	Precipitation.....	--	--	--	--	--	100	--	--	--	--
203	Snow and Ice.....	7	18	2	--	16	47	9	--	--	--
204	Evaporation and Transpiration.....	--	--	--	--	40	60	--	--	--	--
205	Streamflow.....	--	46	--	1	37	16	--	--	--	--
206	Groundwater.....	--	11	29	--	46	11	.5	--	3	--
207	Water in Soils.....	--	--	--	--	100	--	--	--	--	--
208	Lakes.....	15	5	--	--	84	1	1	--	--	--
209	Water and Plants.....	--	--	--	37	63	--	--	--	--	--
210	Erosion and Sedimentation.....	11	21	--	11	56	2	--	--	--	--
211	Chemical Processes.....	--	--	1	64	6	--	27	--	--	--
212	Estuarine Problems.....	29	--	--	--	--	--	--	71	--	--
301	Saline Water Conversion.....	100	--	--	--	--	--	--	--	--	--
302	Water Yield Improvement.....	--	--	--	--	--	--	--	--	--	--
303	Use of Water of Impaired Quality.....	--	--	--	100	--	--	--	--	--	--
304	Conservation in Domestic Use.....	--	--	--	--	100	--	--	--	--	--
305	Conservation in Industry.....	--	--	--	--	--	--	--	--	--	--
306	Conservation in Agriculture.....	--	--	--	69	--	--	31	--	--	--
307	Weather Modification.....	--	--	100	--	--	--	--	--	--	--
401	Control of Water on the Land.....	--	6	--	21	17	56	--	--	--	--
402	Groundwater Management.....	--	80	--	--	--	--	20	--	--	--
403	Effects of Man's Activities on Water.....	2	--	--	--	84	13	--	--	--	--
501	Identification of Pollutants.....	--	4	--	9	86	--	--	.1	--	--
502	Sources and Fate of Pollution.....	--	1	3	11	76	8	.4	.1	.5	--
503	Effects of Pollution.....	6	.9	3	23	66	--	--	--	--	--
504	Waste Treatment Processes.....	21	--	--	--	79	--	--	--	--	--
505	Ultimate Disposal of Wastes.....	18	45	15	--	22	--	--	--	--	--
506	Water Treatment.....	--	18	--	--	82	--	--	--	--	--
507	Water Quality Control.....	3	--	--	66	30	--	--	--	--	--
601	Planning.....	8	--	--	79	14	--	--	--	--	--
602	Evaluation Processes.....	--	47	--	8	44	--	--	--	--	--
603	Cost Allocation, Sharing, Pricing.....	--	--	--	--	--	91	--	--	--	--
604	Water Requirements.....	--	--	--	--	9	--	--	--	--	--
605	Water Law.....	--	--	--	--	100	--	--	--	--	--
606	Institutional Aspects.....	--	--	--	--	--	--	--	--	--	--
607	Sociological and Psychological Aspects.....	--	--	--	--	--	--	--	--	--	--
608	Ecologic Impact of Water Development.....	--	5	--	91	2	--	--	2	--	--
701	Network Design.....	--	--	--	--	100	--	--	--	--	--
702	Data Acquisition.....	--	--	32	--	60	7	--	--	--	--
703	Evaluation, Processing and Publication.....	--	--	--	40	60	--	--	--	--	--
801	Specifications and Design.....	5	58	--	8	23	--	6	--	--	--
802	Materials.....	--	--	--	--	--	--	--	--	--	--
803	Operations.....	--	--	--	--	--	--	--	--	--	--
900	Environmental Health and Protection.....	--	--	--	--	100	--	--	--	--	--

Table 2.12 Distribution of Grants for Water Research
As Funded by NSERC, 1983

Department	Number of Grants	Monies to Grants		Total (\$000's)
		Average Size (\$)	Standard Deviation (\$)	
Civil Engineering	90	16922	6513	1523
Geography and Agric. Engineering	13	14370	7197	187
Oceanography	13	24999	9915	325
Biology/Chemistry/ Botany/Zoology	42	22905	15385	962
Mathematics/Physics/ Earth Sciences	17	15770	11873	268
				Total = \$ 3,265

Notes - figures quoted for fiscal year 1983/84

- some latitude has been used in rounding-off the number in
the above table so as not to imply unwarranted precision.

Table 2.13 Distribution of Strategic Grants for
Water Research as Funded by NSERC

Department	Number of Strategic Grants	Monies to Grants		Total (\$000's)
		Average Size (\$)	Standard Deviation (\$)	
Chemistry/Biology/ Botany/Zoology	20	38745	5296	774.9
Civil Engineering	9	49722	5494	447.5
Oceanography	7	46586	5004	326.1
Mathematics/Physics/ Earth Sciences	3	48267	4176	144.8
Totals	39			1693.3

Table 2.14 DSS Summary of Water Research
Funded Projects (in 1983)

Federal Department Source	Research Dollars to Private Sector (000's)	Research Dollars to Universities (000's)
Environment	872.4	186.8
Fisheries & Oceans	527.2	13.6
Energy, Mines & Resources	197.1	35.8
International Joint Commission	51.1	---
National Research Council	703.4	105.2
Transportation	130.0	---
AECB	23.0	---
Agriculture	103.5	---
Sub totals	2607.7	341.4

- (ii) DSS funding, in combination with the bridge funding required from the sponsoring department, represents an important opportunity to direct research efforts toward designated, priority areas.
- (iii) on the negative side, sponsoring departments have historically had great difficulty in providing even the modest bridging funds required (typically fifteen percent of the total budget), since this type of funds are in extremely short supply (as indicated within both the interview and questionnaire responses).
- (iv) there is bidding amongst departments of the federal government for research monies, with the research money going to universities, if obtained. These funds provide financial support for topics of federal priority.

2.4.8 Research Effort by Educational Levels

Of interest for future personnel needs are the varying requirements for different educational levels. Unfortunately, many of the submitted questionnaires were incomplete, making it impossible to get an accurate determination. However, presuming those questionnaires received are a random set of submissions, then the relative numbers of individuals of varying educational levels involved in research within the sub-categories should indicate the areas of current, greatest involvement. The information available in the questionnaires is summarized in Table 2.15 which indicates the man-years of research effort classified by educational level.

Information on professional staff additions and deletions as reported was rather incomplete -- only specific examples are available.

Specifically:

- (i) NHRI - no major staff changes are planned (the addition of 7 by 1985),
- (ii) NWRI - no staff changes planned,
- (iii) Freshwater Institute - only 10 additional staff planned by 1985.

It is also worthy of note that there are no full-time research scientists in NWRI who will be younger than 35 at the end of 1985 and that 60 percent of the scientists are between the ages of 40 and 49. All of this does not bode well for employment opportunities in the above organizations. Further comments on research personnel and continuing education are contained in Section 3.2.7.

Other submitted information was not in a form for which viable projections could be made. Few additions are expected with current funding levels.

Table 2.15 Man-Years of Research Effort Classified by Educational Level

Code	Sub-categories	Doctor	Master	Bachelor	Student	Technician	Total
101	Properties of Water.....	3.2	1.	.2	---	.4	4.8
102	Aqueous Solutions and Suspensions.....	---	---	---	---	---	---
201	Water Cycle, General.....	8.5	7.4	1.6	.9	4.2	22.6
202	Precipitation.....	---	---	---	---	---	---
203	Snow and Ice.....	21.9	13.4	9.7	1.	11.1	57.1
204	Evaporation and Transpiration.....	3.	.5	.3	.2	.1	4.1
205	Streamflow.....	2.5	5.2	2.4	1.0	6.6	17.7
206	Groundwater.....	3.4	8.0	5.1	---	6.8	23.3
207	Water in Soils.....	---	---	.1	---	---	.1
208	Lakes.....	7.8	1.2	7.9	---	3.4	20.3
209	Water and Plants.....	.5	---	---	---	---	.5
210	Erosion and Sedimentation.....	6.2	5.6	2.6	3.6	5.4	23.4
211	Chemical Processes.....	3.4	4.9	4.1	2.6	4.2	19.2
212	Estuarine Problems.....	2.3	.1	3.4	10.	---	15.8
301	Saline Water Conversion.....	.5	---	2.	---	---	2.5
302	Water Yield Improvement.....	---	---	---	---	---	---
303	Use of Water of Impaired Quality.....	.2	---	2.	2.	---	4.2
304	Conservation in Domestic Use.....	.2	---	.9	---	.2	1.3
305	Conservation in Industry.....	---	---	---	---	---	---
306	Conservation in Agriculture.....	1.1	3.2	4.	2.1	4.	14.4
307	Weather Modification.....	3.	1.	1.	---	3.	8.
401	Control of Water on the Land.....	4.	3.6	1.9	---	.7	10.2
402	Groundwater Management.....	1.2	.2	.4	1.	.5	3.3
403	Effects of Man's Activities on Water.....	.7	3.	1.	.3	1.9	6.9
501	Identification of Pollutants.....	15.6	3.5	3.7	---	13.2	36.
502	Sources and Fate of Pollution.....	28.4	12.2	19.6	1.2	35.5	96.9
503	Effects of Pollution.....	39.6	24.4	23.8	14.1	21.1	123.
504	Waste Treatment Processes.....	.5	.7	.2	.5	.8	2.7
505	Ultimate Disposal of Wastes.....	1.8	.5	1.9	1.1	.8	6.1
506	Water Treatment.....	.5	.2	.2	.1	.2	1.2
507	Water Quality Control.....	5.0	5.4	9.5	6.5	5.2	31.6
601	Planning.....	1.3	3.7	2.	---	.5	7.5
602	Evaluation Processes.....	.4	---	.4	---	.2	1.
603	Cost Allocation, Sharing, Pricing.....	---	---	---	---	---	---
604	Water Requirements.....	1.	---	.3	---	---	1.3
605	Water Law.....	---	---	---	---	---	---
606	Institutional Aspects.....	1.	---	---	.4	---	1.4
607	Sociological and Psychological Aspects.....	---	---	---	---	---	---
608	Ecologic Impact of Water Development.....	1.6	.2	---	.1	.5	2.4
701	Network Design.....	---	.6	---	---	---	.6
702	Data Acquisition.....	1.3	1.7	1.3	.2	3.9	8.4
703	Evaluation, Processing and Publication.....	---	.4	.9	---	2.4	3.7
801	Specifications and Design.....	3.8	6.5	3.	.3	2.1	15.7
802	Materials.....	---	---	---	---	---	---
803	Operations.....	---	---	---	---	---	---
900	Environmental Health and Protection.....	.3	1.3	---	---	.3	1.9
	Total.....	175.7	120.	117.4	50.2	140.2	603.5

Note - in some situations only reported research dollars were provided, but no indication of man-years by educational level were indicated. As a consequence, the above should be considered as lower bounds.

2.5 Examples of Funding Patterns

The previous discussion has provided an overview of water research activity and effort at an aggregate level. In this section, attention is focussed upon two organizations to illustrate the way in which the general trends and patterns manifest themselves within specific organizations.

2.5.1 National Water Research Institute

The National Water Research Institute (NWRI) represents a major component of the water research effort in Canada. Specifically, the Institute carries out a program of research and development designed to meet the objective of providing the necessary information and understanding of water systems for water management problems or opportunities in Canada.

Due to the leading role of NWRI in water research in Canada, a request was made of Dr. G.K. Rodgers, Director of NWRI, to quantify personnel and budget expenditures that have occurred over recent years. The response included the person-year resources as quantified in Table 2.16. From the tabulated figures it is apparent that core staffing is reducing while other staff resources (so-called "soft" sources because of their temporary nature) have remained fairly steady with a small increase in 1984/85. Overall, there has been a slight decrease with time.

The trends in capital and operations and maintenance (O&M) budgets are provided in Table 2.17. The bracketed values following individual entries represent adjusted values to 1983/84 fiscal year dollars using a consumers price index. Noteworthy points regarding the indicated values include:

- (i) O&M reported values do not include salaries,
- (ii) the values in capital trends are largely all in research with approximately \$160 k to \$200 k being used in support of field operations and calibration/assurance services. The variations in the levels for supplementary capital are directly attributable to specific initiatives, and explain much of the variability in the total funding levels, the last row in the table;
- (iii) the O&M A-base is subdivided into building/administration and research/R.S.A. Noteworthy is that building and administration costs have increased whereas research allocations have decreased, with the total O&M A-base dollars remaining essentially constant;
- (iv) supplementary funding to O&M is variable from year to year. These funds are a measure of direct support from NWRI clients including Canadian Climate Program, Program for Energy R&D, Great Lakes Water Quality Program (special allocation to Regional Director General), Toxic Chemicals Management Program and Long Range Transport of Airborne Pollutants.

Table 2.16 NWRI Person-Year Resources

	Fiscal Year			
	1981/82	1982/83	1983/84	1984/85
Regular Staffing	262	260	254	250
Others ("soft sources")	8.5	7.5	8.9	11.75
Grand Totals	270.5	267.5	262.9	261.75

Table 2.17 NWRI Funding Trends

	Fiscal Year				
	1980/81	1981/82	1982/83	1983/84	1984/85
<u>Capital Trends</u>					
Core A-Base Capital	903(1189)	982(1151)	1324(1401)	1461(1461)	1407(1349)
Supplementary Capital	255(336)	938(1100)*	243(257)	714(714)**	196(188)
<u>O&M Resource Trends</u> (salaries not included)					
Building & Administration	1615(2128)	2046(2398)	2280(2413)	2503(2503)	2760(2646)
Research and R.S.A.	2166(2854)	2153(2590)	2428(2569)	2384(2384)	2369(2272)
Total A-Base	3781(4982)	4199(4922)	4708(4982)	4887(4887)	5129(4918)
Supplementary Funding	740(975)	1259(1476)	934(988)	1483(1483)	980(940)
<u>Totals</u>	5679(7482)	7378(8649)	7209(7628)	8545(8545)	7712(7395)

Notes - all budget values in \$000's

- bracketed values are estimated 1983/84 dollar values using the consumers price index as an adjustment factor

* major toxic chemical instrumentation program

** renovation of water quality lab/WQB centralization at CCIW

The most important finding from the above information is that with respect to both person-years and research dollars, the resources available to NWRI are decreasing with time. Since NWRI is definitely a leading agency for water research in Canada, this finding is distressing.

2.5.2 Westwater Research Centre, University of British Columbia, Vancouver

The Westwater Research Centre is a part of the Faculty of Graduate Studies at the University of British Columbia. Its role is "to carry out studies of policies and methods of managing natural resources" (Westwater Research Centre, 1984). Its research program currently has several thrusts including coastal resources of British Columbia, water quality management, northern water resources planning, and international water resources management. To conduct its work, Westwater has a permanent staff of university professors and research associates with expertise in law, planning, economics, political science, geography, marine ecology, fisheries, biology, and environmental chemistry. Although the University of British Columbia now pays for the core budget of the Westwater staff, "it is intended that Westwater be as self-supporting as possible and, therefore, that its project budgets cover staff time as well as travel, office and publishing expenditures" (Westwater Research Centre, 1984).

Westwater was one of six university programs across the nation to receive development support from the Inland Waters Directorate in the early 1970's. The intent was to encourage and develop different aspects of water research expertise in various regions of the country. Westwater was established in September, 1971, with a development grant of \$90,000 provided by the Inland Waters Directorate of Environment Canada. In the second year of operation (1972-1973), half of the first grant was carried over to be combined with a second grant of \$180,000 from Environment Canada. In the first two years of operations, Environment Canada was the only source of funds for Westwater and the research focussed upon water quality in the Lower Fraser River.

During 1973-1974, Westwater received a third grant of \$180,000 from Environment Canada. However, other funding also was obtained, with \$25,000 received from the Rockefeller Foundation in August 1973 to support research on international river basin developments (Ross Dam on the Skagit River, Columbia River Treaty between Canada and the United States; pollution of the Rhine River, shared by Switzerland, West Germany, France and the Netherlands).

By 1974-1975, the development grant funding from Environment Canada was decreased to \$157,000. However, funding sources were becoming diversified. The first contractual work for Environment Canada generated \$22,500. A Canada Council grant of \$33,360 was received for institutional studies regarding the Fraser River. Summer student funds from the federal and British Columbia governments allowed students to supplement the staff. In addition, the first funds (\$16,000) from the province supported a conference, and funds (\$10,690) from the Vancouver Foundation allowed continuation of a lecture series which had been initiated with earlier Environment Canada funding.

The year 1974-1975 also was significant in that the University of British Columbia began to fund the core staff at Westwater with \$10,197. In 1975-1976, the University increased its core funding to \$60,870, which was the beginning of a financial arrangement under which core staff held joint appointments in Westwater and an academic department. By 1984-1985, the six academic core staff each had a portion of their salary ranging from 25 to 80 percent provided through Westwater with the balance coming from departments or schools as diverse as Law, Community and Regional Planning, Civil Engineering, Forestry, Soil Science, and the Institute of Animal Resource Ecology. It has been suggested that "the continuing commitment of the University to a core capability has been a major factor in determining Westwater's success" (Dorcey, 1985, 2).

During 1975-1976, the Lower Fraser Pollution Control Program, which had been the major activity funded under the Development Grant program of Environment Canada, came to a conclusion. A new initiative focussed upon coastal resource management, with particular regard to estuaries. By 1976-1977 the funding from Environment Canada fell to \$88,000, and support from the University increased to \$93,000. In that year, \$40,000 provided by the Rockefeller Foundation facilitated further research on the management of international rivers.

The next year was devoted to preparing a major proposal to Canada Council for a negotiated development grant to support an integrated set of natural and social science studies on coastal resources. This proposal was unsuccessful, and led to some fundamental decisions regarding the type of research Westwater would pursue. As the Assistant Director (Dorcey, 1985, 2) explained:

"It was at this point that we concluded that we would never be able to convince the Councils to fund applied public policy research that integrated both the natural and the social sciences (this has continued to be our experience with several subsequent submissions to NSERC and SSHRC). We decided that we would have to adopt a strategy of piecemeal funding the components wherever possible and then integrating them as best as possible as part of the conduct of the research. This is why you see a more diverse program and variety of funding sources in the years following".

This recognition of restraints upon funding for interdisciplinary and/or non-traditional research activity also led to termination of a quarterly newsletter and the annual Westwater Lectures Series. These highly successful extension activities had been conceived as mechanisms to inform managers and the general public about the results and implications of research at Westwater. However, despite the occasional special newsletter and one further lecture series, the Centre had to rely upon its own publication series as well as publishing in journals to disseminate research findings and conclusions.

Funding from Environment Canada continued, but on a decreasing level of support: \$88,000 in 1977-1978; \$60,000 in 1978-1979; and \$22,000 in 1979-1980. Funding from the Inland Waters Directorate continued to trail off and after 1982-1983 Westwater stopped applying for support. At the same time, other sources were pursued. Projects and funding sources became diverse: mariculture research supported by British Columbia; pollution control in the Fraser River with funds from the National Research Council; international water management in Africa under the Ford Foundation, Rockefeller Foundation and Resources for the Future; environmental regulations for the Economic Council of Canada; a training and research program in Peru through the Canadian International Development Agency; the continuation of coastal and northern research programs supported by a variety of sources including the Max Bell and Donner foundations.

A key point which emerges is the time and effort which the staff at Westwater devote to the discussion, preparation and presentation of research proposals starting in the mid 1970's. Since rarely would one funding agency consider an application which was applied, policy-oriented, and interdisciplinary, many smaller proposals had to be prepared which addressed the mandates or interests of sponsors. When some of the proposals were not funded, then it became difficult for the pieces to be integrated.

Notwithstanding the continuous tension created by the need to obtain funding, Westwater has been one of the most successful of the research centres which were started in the early 1970's by seed money provided through the Inland Waters Directorate of Environment Canada. It continues to operate an active and sustained research program, whereas other initiatives such as the Agassiz Centre at the University of Manitoba have been closed. Westwater has received substantial funds from the federal and provincial governments, private firms, and foundations. Its publication program has been substantial, with some 18 books and 28 reports listed in its publication guide. In addition, numerous chapters in books and articles in periodicals have been published by the researchers at Westwater.

On the other hand, a question remains about the instability and uncertainty associated with funding. A significant consequence is that a very talented team of researchers is placed in a position in which a substantial portion of their time and effort is devoted to administrative and fund-raising efforts, rather than to the actual conduct of research. In the long-term, the consequences of this type of situation could be substantial and serious.

Chapter 3

ISSUES AND CONCERNS PERCEIVED TO INFLUENCE RESEARCH EFFORT

3.1 INTRODUCTION

The intent of this chapter is to focus on the subjective response information obtained during the study. The current arrangements and level of effort were presented in Chapter 2, whereas the focus of this chapter is primarily to summarize the perceptions of pertinent aspects of water resources research as currently being carried out in Canada.

3.2 SUMMARY RESPONSES DERIVED FROM THE QUESTIONNAIRES

The most interesting findings related to the subjective aspects of the questionnaire are described below.

3.2.1 Continuing Education Issue

Concerns with the need for continuing education were those mentioned most frequently in the questionnaire responses. Historically, one successful means by which professionals updated their knowledge was through the hiring of new employees. The transfer of technology then occurred by the working association. However, the opportunities for hiring, apparently, in all sectors of employment (government, private and university) appear limited with the likelihood that this mechanism for continuing education opportunities is becoming very limited.

At the same time, opportunities for attending conferences and continuing-education short courses have been extensively curtailed because of budget limitations. Some professionals are attending at their own expense but obviously this is not an option available, nor supported by all. The awareness of "who is doing what" and "who to contact to find out the latest specifics on research" is thus being seriously curtailed.

Some programmes exist for upgrading of technicians but such opportunities for professionals are very limited. Individual professionals are generally not in a position for retraining themselves by, for example, taking time off without pay. The concern with obsolescence and need for continuing education was extremely widespread.

Unless the results of research reach users quickly, in a readily usable form, their value is limited. Further, unless research results are known to other researchers as soon as possible, unnecessary duplication of effort is possible. Thus, transfer of technology problems and communications must be addressed.

Several possibilities exist to overcome aspects of the problems with continuing education but none are likely to succeed unless some initiatives currently not in place, are enacted. The initiatives include:

(a) to have sabbatical opportunities provided for industrial and governmental people. These sabbaticals may involve one of a series of

initiatives including individuals receiving term or year-long appointments to universities.

(b) to have increased offerings of short courses. Because of Canada's limited population and high travel cost, one scenario suggested was to use the EPA model where the short course instructors offer the course in a series of locations. The fees in these courses are minimal, with the fees and transportation/living costs of the instructors being underwritten by EPA.

(c) it is not apparent that universities are currently well organized to give "re-treading", but this should be changed.

3.2.2 Changes to Improve the Capacity of Federal Programs to Respond to Changing Priorities

The question related to the changes that should be made to improve the capacity of federal research programs to respond to changing priorities elicited considerable response.

Federal employee responses encompassed the range from difficulties associated with "inhouse" organizational problems, to how inhouse research programs might be enhanced by improved communication with professionals outside the government.

Specifically:

- (a) "the growth of bureaucratic demands on scientist time should be limited" and "recognize research as a legitimate government activity and not something to which only lip service is given" are two representative comments made by federal research scientists that express strong, but fairly widely-held opinions;
- (b) resource allocations have been made simply on 'regional parity', rather than on proven competence and performance excellence. This response expresses one element of the important trade-off between centralization and regionalization of federal resources.
- (c) there should be an improvement in the use of post-doctoral fellows as a means of increasing numbers of professional staff to carry out the research. Reduced resources available to federal groups have almost eliminated use of post-doctoral fellows.
- (d) a large portion of research should be 'market-driven'. Secondment arrangements with industry and universities should bring a team of professionals together to address a specific priority for a specific term.

All of these comments would appear to have merit for making changes to the existing system.

3.2.3 Changes to Improve Coordination of Federal Programs

This question also elicited widespread response, with differences in opinions expressed in response to category of employment. From the federal sector, the comments included:

- (a) A coordinating mechanism among federal departments should be established, not to direct research but to provide guidance and leadership. University representatives were suggested as potentially being involved.
- (b) There is inflexibility in resource allocations within the federal sector. There is overlap and, even worse, partially complete research efforts because departments are unwilling to transfer money or manpower to research programs outside their control. This criticism relates back to an oft-expressed concern that promotion in the federal sector is related to the pyramidal structure of people beneath them - if money is transferred out or remains unspent, then changes may be made to restructure a group's organization.
- (c) another comment that is distressing in some respects is "don't expect private consultants to do research from federal funding. Let them do the short-term applied work for which they are organized". This comment shows a strong bias on the part of federal researchers, and to some extent, a shortcoming of the structure of the organizations of private consultants. This funding allocation is certainly dramatically different from the U.S. approach which has extensive research being done in the private sector - the question then arises "whether the consultants' structure is the result of the funding" or "is the lack of funding provided creating a structure capable of doing only short-term applied work" (if the latter structure actually is the situation).

With a large organization, it is difficult to identify changes that should be made but, regardless, frequent comments were made that argued for enhanced flexibility at a minimum.

Consultants' comments on this issue include:

- (a) an 'on-line' record of ongoing research activities cross-referenced by agency, topic, principal researchers, disciplines, funding source, etc. should be established. This comment relates to enhanced needs for communication.
- (b) there is a need for a national institute to develop long-range viewpoints. Presumably, this function should be provided by the existing NWRI and NHRI but, at least to some extent, this role is not functioning.
- (c) some obvious dissatisfaction with decision-makers within the federal sector (presumably those associated with deciding the recipients of research funding). The comments included "decision-makers are normally out of touch with reality" and "fire the dinosaurs". Whether these opinions are valid is unknown but the simple fact that the comments were made shows dissatisfaction that warrants some consideration by the federal sector.

Consultants and university personnel comments included: "Stop changing people's jobs every two years into new positions they know nothing about". The "all-too-frequent" response of federal researchers is that since they have only been in their position for x months, they don't know what is going on.

3.2.4 Time Durations Before Appearance of Research Results

A major difficulty with existing research is the time required before improvements are derived. The considerable time-lag occurs because the following occurs:

- (i) an individual recognizes a need;
- (ii) research work is done;
- (iii) the results are published;
- (iv) with appropriate findings, the media publicize the work;
- (v) political pressure is developed; and,
- (vi) Treasury Board approves financing.

In the cases of toxicology and acid rain, steps (i) through (vi) required ten years. As a follow-up, to actually observe an improvement in the environment, a number of additional years are required. For example, it was another 25 years, for a total of 35 years, before significant improvements in lake eutrophication of Canada's water bodies started to become apparent.

In a quest for reducing the time duration before the appearance of the results of research, it appears that a new approach must be adopted. Current procedures for funding tend to promote research by committee. Psychologists have found that only one member of a committee needs to speak strongly to "sink" a proposal; thus, "arrogant upstarts" suggesting radical ideas tend to be suppressed and yet it may be a radical idea that will provide a significant breakthrough.

An approach to possibly preventing the difficulties discussed above is to create a new set of managers. This set of managers of research would have a specific budget set aside to fund research that has a risk of "not going anywhere". With the current system, managers are afraid of being wrong and tend to practice "safe" science. The opportunity of a "super" group with risk capital entails a potential mechanism for discovering breakthroughs while accepting the knowledge that some failures will occur. Such a "portfolio" approach may provide opportunities to decrease the duration for research results to be developed.

3.2.5 Duplication in Government Efforts

Although some duplication in research effort funded by the federal government was acknowledged, the survey responses indicated that such duplication as exists, is beneficial. The consequent checking-of-results and degree of competition that arises from such duplication is favourable.

On the other hand, some strong criticisms have been levelled at the current operational mode viz, "as a result of federal policy on research funding, research on Canada's water resources in general has become monopolized by government scientists" (Great Lakes Institute, 1984). As well, research efforts dispersed across Canada, instead of being carried out in a few centres, increases the awareness of local issues and benefits local economies -- although there are numerous detractors from decentralization policies.

3.2.6 Need for Inter-Group Research Efforts

In many cases the scientific investigator's research options are narrowly defined in accordance with departmental mandates and current bureaucratic organizational frameworks. In such circumstances it is unreasonable to expect environmental scientists to be very effective at producing meaningful information issues that are interagency, interdepartmental, interprovincial and international.

Competition between water uses is not only growing but the potential for more serious conflict between uses is inevitable. These concerns must be reflected in future research funding policies, to reflect the need for greater inter-group research efforts.

3.2.7 Age-Distribution of Researchers

Government policies to curtail in-house research have meant that few new professionals have been hired over the past decade, into government research groups. The average age of professionals in the public service has consequently increased during this time with the average age now being approximately 47. New professionals are not being added to the public service in sufficient numbers for the research institutions to benefit from the normal transfer of knowledge from older to younger staff, nor for the older staff to learn of new developments from the younger staff.

In combination with the cutbacks in opportunities for retraining, and attendance at conferences, the result has been an undermining of the feelings of self-worth and mission that the public service had in the 1950's and 1960's. Because of the relatively-young average age of professionals, the concern expressed so frequently in the survey of pending obsolescence is a very great problem which, without a change to the existing structure, will be a problem for many years into the future.

It should be noted that in the context of aging researchers, programs such as the Canada Works program accomplish little. Although useful for providing resources for "legwork", little contribution to "heavy thinking" occurs.

3.2.8 Termination of Data Collection Efforts

Data collection efforts provide an essential element of research studies. However, data collection programs have the characteristic of continuing in perpetuity. The decision-making system to identify when data collection efforts should be terminated, is not generally

available. If, for example, a saving of 100 person-years were to be created by the introduction of a new piece of data collection equipment or the identification that the collection efforts should be terminated, the loss of the person-years would probably create a down-grading of a boss's job. A considerable resistance to such changes thus develops.

3.2.9 The State of Canadian Journals Dealing with Water Resources

In response to the question asking whether Canadian researchers are happy with Canadian journals, the response was "yes", which is a good testimonial to the sophistication and quality of the existing journals. It appears that individual researchers are not likely to increase their publishing significantly in Canadian journals since there is a limited audience, and particularly, little recognition at an international level arises from technical papers published in these journals. As well, most papers are published where the author(s) feel most of the targeted readership lies. The result is that a continuation of the existing effort in Canadian journals is appropriate to upgrade and improve but no expectation of large changes in operational mode should be expected.

3.2.10 Priorization of Major Constraints on Research Productivity

Of interest was an identification of the major constraints on researcher's productivity - shortage of funds, time, shortage of personnel, shortage of technicians, inadequate space, inadequate equipment, other (?).

Rankings as indicated by university researchers, by no means unanimous, were (a) funding, (b) time and technical personnel, and (c) space and lab equipment. Additional comments received that indicate important concerns include:

- (a) "significantly large amounts of funds need to be committed for three to five years at a time to allow one to offer satisfactory employment to competent research associates". A related response frequently made was "many students and funds are available but the need is for people (with experience) to supervise the day-to-day work".
- (b) "freer access to the equipment and facilities at government labs would greatly aid university researchers". This opportunity would appear to be a valid consideration to be explored.
- (c) increased funding would allow solving any of the above-mentioned problems. However, some responses were very strongly worded including "all of the above are priorities. We are starving - if we were mildly undernourished, priorities might be established". This type of comment typifies the very emphatic attitudes of numerous university researchers.

Ranking by government researchers were (a) professional personnel, (b) technical personnel, (c) funding, (d) equipment and space.

3.2.11 Proposal Preparations by Researchers

The responses to the question asking how many proposals were written and the major reason why more proposals were not written provided some interesting responses on the state of water resources research in Canada. This question was directed specifically at university professors to better identify existing constraints on research levels and how changes to existing funding levels might change the system. Responses provided an interesting set of insights, including:

- "the bureaucracies of the funding agencies versus the monies they have to award make the exercise hardly worth the effort".
- "the administration of small projects takes excessive effort".
- "problems of time between notification of grant programs and deadline of submissions were not sufficient to prepare properly".
- "I had more work than I could do, without making any more proposals". On a similar note, "I did not submit more proposals because of limits on my time and the absence of support personnel". For active researchers there are apparently many constraints on time that could be alleviated by the addition of professional support personnel who could assume some of the supervisory role of research.

As for numbers of proposals prepared and funded, a great variability was readily apparent from the questionnaire responses. Some researchers reported a very high success rate on proposals submitted - it appears that the individuals who themselves are very good/well-connected to scientific contract officers, prepare good proposals, have high acceptance rates on proposals and very active research programs.

3.2.12 Attitudes Toward "Buy Out" by University Professors

Significant interest is being expressed by some university researchers in the opportunity to "buy out" from some of their teaching tasks. The intent is that research money is used to hire other individuals to assume some (but not all) of the teaching responsibilities. The pros to such an opportunity include freeing some time for the professor to devote greater time to research and the opportunity provided to bring additional personnel into the university environment, albeit for a limited tenure.

The cons to the buy out policy include the potential for abuse by excessive utilization of the buy out procedure and the potential for inappropriately prepared and/or committed individuals to be involved in teaching.

The response to the question posed in the questionnaire resulted in 26 in favour and 12 against the buy out procedure. As a result, there is majority support which indicates that the policy should be considered -- the policy cannot be a success, however, unless changes are made to the existing funding guidelines of most funding agencies.

Professors need to illuminate their teaching with their own research experience and the most productive researchers should also have the opportunity to train tomorrow's researchers.

3.3 SOME SUMMARY FINDINGS

The subjective aspects related to water resources research discussed in this chapter are far-ranging and to some extent represent elements of a "wish list". Regardless, the information summarized should be carefully evaluated since there are some important messages contained herein. Some changes would be easily enacted, whereas others would represent major adjustments from current operational modes.

The intent herein is to indicate below some fairly specific changes that should be given very serious consideration:

- (i) communications between professionals should be enhanced. Such enhancements may assume many forms but should include: a catalogue indicating sources of funding to improve the awareness of researchers of the existing sources and objectives; secondly, improvements in indicating who is undertaking various types of projects, with contact addresses and phone numbers; improvements in data management and availability should be made;
- (ii) a great need exists for programs directed toward the retraining and continuing education of research professionals;
- (iii) a water resources research advisory committee should be formed to develop statements of needed research, on a regular basis;
- (iv) some "risk" funding to support research that may provide significant breakthroughs should be created. As a part of such a structure, supervisory professionals should not be "hailed upon the carpet" when failures do occur;
- (v) as related to university funding of research, additional long-term funding is needed to increase opportunities for full-time researchers. Such individuals could assume some of the supervisory effort of graduate students, could learn from the ongoing research as well as provide employment opportunities not currently available;
- (vi) consideration should be given to increasing federal assistance perhaps on a matching grant basis, to increase the research expenditures being made by the private sector.

Chapter 4

PRIORITY AREAS FOR FUTURE RESEARCH

4.1 INTRODUCTION

During the public hearings, the workshop and the review of pertinent material, a broad array of research needs was identified. These needs ranged from general concerns with pollution, flooding and water supply, to very specific concerns such as farm-related contaminants into water bodies, peatland water resources, river ice processes, estuary hydrodynamics to freshwater in the boreal plains. In this chapter the focus is upon those water research needs which are of national significance and therefore of concern to the federal government.

4.2 PRIORITY RESEARCH NEEDS

On a regional basis, Atlantic Canada appears to have been least well served regarding water resources research by the federal government. No national research institutes, nor affiliated branches, are located in Atlantic Canada. In contrast, other regions of the country have at least a branch of a national research institute located in their area. Thus in substantive terms, Atlantic Canada should receive at least a regional research office. British Columbia now has a branch of the NWRI. It has been reported that the branch will be transferred to Saskatoon when the new building for the NWRI is completed. If that occurs, British Columbia will be without a regional research centre and may find that some of its regional needs are not satisfied.

Regarding major water-related problems, a number of issues remain. While inventory and monitoring programs exist, there still is not an adequate understanding of the basic nature of the water resources. Initiatives in this area often will have to be pursued in cooperation with the provinces, but the goal should be to steadily expand and upgrade inventory and monitoring networks so that the quantitative and qualitative aspects of the water resource are more clearly defined.

In addition to improving our descriptive knowledge of water, effort is needed to improve our functional knowledge, especially with regard to the following topics. Groundwater deserves much more attention. In addition to improving technical knowledge of groundwater resources, there is a need to clarify the legal and economic considerations related to groundwater.

Water diversions or transfers also deserve attention. While public attention often focusses upon the possible impacts of international transfers, many transfers already have been implemented within Canada. Quinn (1981, 68) identified approximately 60 water transfers scattered across nine provinces, the majority developed for hydropower generation, with irrigation, flood control and municipal uses assuming some importance at a regional scale. That number provides a substantial base of experience from which to analyze the environmental, economic and social impacts of transfers. Improved understanding of those

experiences should be invaluable as the possible impacts of transfers in the future are considered.

Water quality attracted the most water resources research effort in the 1970's and early 1980's, and will continue to be a major issue in the future. Increasingly-sophisticated monitoring equipment is allowing identification and measurement of pollutants which in earlier decades could not be traced. The continued monitoring of these pollutants, especially in interjurisdictional water bodies, will continue to require vigorous federal research effort. Disposal of toxic wastes represents a particular problem with extensive implications for water quality, given the possibility of leakage and migration of such wastes from underground storage sites. Since leakage or migration of toxic wastes poses a potential threat to water supplies, research focussing upon handling and storage is necessary. Given the serious implications of acid rain for regional economies combined with the international dimension of the issue, the federal government also should continue to maintain an active research program so that Canadian negotiating teams can be supported by the strongest possible evidence.

Environment Canada (1983, 41) estimated that as many as 200 communities across the country have potential flooding problems. The National Flood Damage Reduction Program introduced in 1975 has given a strong incentive toward developing a more balanced approach using both structural and nonstructural adjustments. Given the fairly recent use of nonstructural adjustments, further research is required. Priority areas of research could include the impact of floodplain designation on property values as well as the conflict between realizing flood damage objectives and the preservation of heritage structures located on floodplains. While these types of issues do not have the profile or visibility of international water transfers or acid rain, they are more likely to impact directly the day-to-day living of individuals. Thus, federal research activity should attempt to achieve a balance among these various types of issues.

Many submissions to the Inquiry called for more attention to demand management. As this is still a new concept and therefore either not understood or else misunderstood by many people, the federal government, in cooperation with others, should take a lead role through its research program to identify and clarify options in demand management. This area also is an excellent candidate for the development of demonstration programs and projects which would facilitate public understanding of demand management as well as permit systematic assessment of the effectiveness of some of the strategies (Tate, 1981, 164-166; Mitchell and Robinson, 1984). As demand management can have implications for residential and industrial water supply, irrigation systems as well as wastewater treatment systems, it should be given high priority in a federal research program. Furthermore, if demand management is to be developed, a parallel effort is required to improved demand forecasting models.

In the submissions to the Inquiry, it often was argued that many water problems such as non-point source pollution have their basic causes in associated resource systems. Consequently, there is a real need to strengthen research efforts which cut across resource sectors

and also cut across the mandates of various federal government departments. One of the motives behind the creation of Environment Canada was to place responsibility for renewable resources within one agency. While that was done, there is evidence that the various directorates or services often "go their separate ways" in the conception and implementation of research activity. If some of the more complex and enduring water problems are to be resolved, more research activity must be designed to draw upon the skills of investigators in a variety of agencies. Simultaneously, granting organizations should alter their procedures to better accommodate applications for interdisciplinary, policy-oriented studies based in universities and the private sector.

4.3 MAJOR THEMATIC NEEDS

In Section 4.2 needs were discussed with reference to different substantive water issues. In this section, research needs of a more general, or thematic, nature are identified.

4.3.1 Efficiency of Water Use

Although Canadians are extremely fortunate in the water resources generally available, there are both regions of shortages and considerable potential economies which could be realized through increased efficiency of water use. Research is needed to identify more effective ways of using water for a variety of purposes including domestic, industrial, agricultural and hydro electric use. This concern with efficiency should also lead to much more attention in research to analyzing alternative demand management strategies, as was discussed in section 4.2.

4.3.2 Estimating Impacts of Water Development

An improved capability is required to quantify the impacts from water-related development. Work is especially needed with respect to both ecological and social impacts which cannot always be measured in dollar terms.

4.3.3 Incorporating Risk and Uncertainty

Better procedures are needed to accommodate the presence of risk and uncertainty in water management and development. In water resources development the unavoidable existence of a probability of failure requires improved methodologies to reflect the trade-offs between benefits, costs and risk elements.

4.3.4 Conflict Resolution

Since there are many, and often conflicting, legitimate values and interests associated with water management and development, research concepts and methods which could contribute to resolution of conflicts would be very valuable. Over the last decade there has been an emergence of research focussed on conflict resolution but involving a variety of approaches (gaming, bargaining, and environmental mediation). There is a need for work which integrates these different approaches and

contributes to the drawing together of both qualitative and quantitative information.

4.3.5 Integration of Engineering, Natural Sciences and Social Sciences Analyses

Another type of research needing support is work integrating engineering, natural science and social science research. Existing funding organizations do not easily handle research proposals which cut across disciplinary or professional boundaries. A systematic review of policies and procedures used by the major funding agencies to deal with interdisciplinary research is needed, as researchers have expressed considerable frustration and disappointment with current arrangements.

4.4 AN ADDITIONAL CONSIDERATION ABOUT RESEARCH NEEDS

It should be emphasized that there are literally thousands of legitimate water research projects which can be identified and justified. However, in this chapter, attention has been directed to research needs of a more strategic nature. From each one of the strategic areas, a host of individual research projects could be developed. The criteria for selecting priority research needs here has related to issues deemed to be of national significance, pertinent to the federal government.

For those interested in a detailed inventory of possible research topics, both by water sector and by region, the report by LeFeuvre (1984) provides an extended and detailed list.

Chapter 5

A STRATEGY FOR WATER RESOURCES RESEARCH

5.1 INTRODUCTION

Having reviewed research trends and patterns, and examined issues and concerns, it is appropriate to consider what might be the components of a strategy for water resources research in Canada. Several general observations are necessary. First, while a primary purpose is to indicate the federal role in water research, that task cannot be approached in isolation from the potential role of other groups and interests. As a result, an objective here is to define the characteristics of a national strategy, and then to indicate the role of the federal government within such a strategy. Second, it is recognized that any strategy will have to accommodate at least two components: the substance of research and the process of research. Third, it is appreciated that a number of alternative strategies is available. Each has strengths and weaknesses. None is perfect. As a result, an objective is to identify alternative strategies and their relative merits. And fourth, it is acknowledged that the feasibility of any strategy is related to the funding which is provided. Thus, it is important that attention be given to the level of financial support for water resources research in Canada.

5.2 THE COMPONENTS OF A NATIONAL STRATEGY

If a national strategy for water research and related scientific activity is to be developed, a number of basic functions must be fulfilled. An adequate inventory of water resources regarding both quantity and quality is needed. If trends and patterns are to be identified, systematic monitoring must occur. Inventory and monitoring are needed to provide basic descriptive knowledge of the water resource. Other activity must occur if functional knowledge or understanding is to be realized (Dorcey and Hall, 1981, 7-13; Dorcey, 1984, 2-5).

Functional knowledge can be developed in several ways. Desk analysis involves the examination of existing information with regard to given problems or issues. It also will be used in the assessment of policies, programs and projects and is frequently relied upon in social science research. Experimental research involves the testing of cause-effect relationships, often in laboratory settings. This research usually is associated with the natural, life and engineering sciences. Experimental management may be combined with or follow from desk analysis or experimental research. The purpose is to explore on a constrained scale some of the implications of the functional knowledge which have been developed.

If research is to be supportive of water management, the stage of experimental management should be a key component of any national strategy. However, two other components also are needed. Technology transfer should be an explicit part of a research strategy. In other words, if research is to contribute to resolution of societal problems, resources must be provided to facilitate the development of new ideas to the stage where they can be adopted by potential users. Another

important component is education and training. Research not only should contribute innovative ideas and products but also should serve as a vehicle to educate future investigators as well as to help current researchers improve their skills and talents.

Thus a national strategy for water resources research and related scientific activity should have the following seven components:

- (1) inventory
- (2) monitoring
- (3) desk analysis
- (4) experimental research (laboratory and field)
- (5) experimental management
- (6) technology transfer
- (7) education and training

5.3 CRITERIA FOR ASSESSING ALTERNATIVE APPROACHES

While there is strong support for a significant federal role in water resources research, it is important that any such research effort be managed as effectively as possible. In that regard, explicit criteria help to identify the relative merits of alternative approaches. Five criteria are used here to facilitate a review of alternatives, namely:

- (1) coordination
- (2) efficiency
- (3) anticipatory
- (4) user-responsiveness
- (5) balanced perspectives

Coordination of research effort at a national scale is probably the most important criterion, given the distribution of research effort among and within many organizations. If "care must be taken not to fragment the effort" (Canadian Water Resources Association, 1984, 17), then both research effort and activity across the nation and among various sectors need to be integrated and coordinated. Without such coordination, there never will be an optimized national research effort whose benefits should, and can be, greater than the sum of the individual parts.

Efficiency also is a key concern, even accepting that many of the products or services from research are of an intangible nature and therefore difficult to treat in benefit/cost or other quantitative terms. Nevertheless, even if efficiency of research cannot be always measured directly in quantitative terms, awareness of this criterion can guide a more qualitative review and direct attention to more obvious instances of duplication and overlap.

A national strategy should stimulate anticipatory research. As Ayles (1984, 2) explained this concept, anticipatory research has a mission orientation but not in the sense that it is striving toward solution of a particular problem which is widely apparent. In contrast to that latter type of work, anticipatory research "is directed toward the research of the future. It should be aimed at providing distant early warning systems for the future "dioxin problems" and "acid rain" problems".

A key element of anticipatory research would be encouragement for investigators to tackle the really complex and difficult problems. Too often, the present system provides a disincentive for addressing difficult problems. As Cardy (1984, 2) observed, "where results count, where output is measured and solutions are required, it may appear more rewarding to go after the easier problems rather than those that may remain insoluble". Thus, a system is needed which provides incentives for futures-oriented research which addresses the really difficult problems and may not always be "successful".

Expressed in another way, there is a need to encourage research which is of a high risk nature in the sense of not providing immediate and direct results. As Wright et al (1984, 5) observed in their report dealing with technology development in Canada, encouragement of high risk research is not readily given since "in government, ..., acknowledgement of failure is often postponed as long as possible. ..Public servants and their political masters are, by nature, risk-averse; research and development, by its very nature, is an exercise in the management of risk. It is not a promising combination".

Some tension will occur between anticipatory research and research which is user responsive. User responsiveness requires that a portion of research effort should relate directly to the needs of users, whether these be government line agencies or the private sector. For this to occur, there must be much more interaction between the researchers and the managers or users. In this regard, Dorsey (1984, 1) has argued that the most fundamental question has often been ignored - "how can we design a process for setting research priorities so that they better meet the needs of water resources managers?"

The final criterion outlines the need for balanced perspectives in research. A mechanism is required to ensure that appropriate attention is directed to technical, economic, social and environmental aspects of water issues and problems. In addition, there is a need to ensure that social science research activity is given reasonable weight relative to the natural and engineering sciences (Dorsey, 1984, 8; Spence, 1984, 3). Furthermore, a need exists to facilitate interdisciplinary and policy-oriented studies (Ashton, 1984, 4; Dorsey, 1984, 7; Slivitsky, 1984, 10).

Other criteria might be included, and could lead to emphases upon different approaches to research. However, in this review, the five criteria indicated at the outset of this section will be used.

5.4 ALTERNATIVE APPROACHES: STRENGTHS AND WEAKNESSES

A number of alternative approaches which combine the research components (Section 5.2) and criteria (Section 5.3) are identified here. The components and criteria are not used in a matrix-like fashion to assess the alternatives, but rather as general guidelines to direct the review. It also should be recognized that while the alternatives are discussed one by one, several of them could be combined to make a larger "package".

5.4.1 Status Quo

The existing situation is characterized by a strong federal role in research, both as a "doer" of research by its own agencies and as a "facilitator" of research through contracts and grants to others (universities, and the private sector). A basic inventory and monitoring program is in place, and a range of desk analyses, experimental research and experimental management occurs. Education and training is supported through block grants to the provinces for post-secondary education, and by research grants and scholarships to faculty and students. However, upgrading and re-training of scientists within the federal system is not easily handled. Technology transfer is in a stage of infancy, with only a few well supported demonstration and transfer programs (such as the demonstration project for sludge incineration being funded by the Wastewater Technology Centre).

Given the number of participants distributed among many organizations involved in research, a need exists for improved coordination to ensure that effective use is made of the research talent available within the country. No effective mechanism seems to exist to coordinate water resources research at a national level. In the interests of efficiency, laboratories and other research activity have been centralized during the past years. This centralization has generated concern for some that water problems in some regions are neglected. Due to the regulatory mandates of the lead water agency, Environment Canada, much of the research effort is directed by the program needs of line agencies. Relatively little anticipatory research can be done within the federal government, and as the water research funds available to the universities were sharply cut in 1979, anticipatory research is at a modest level there as well. A balanced perspective in research is still being sought. A relatively small social science research effort exists, although there is some fine work occurring at selected places in the country. Proposals for interdisciplinary, policy-oriented work conducted outside of the federal government experience difficulty in obtaining funding due to the structure of funding or granting agencies.

Thus, while water-related research of international calibre occurs in Canada, the current system is not perfect. The alternative approaches discussed below do not imply a discarding of much of what is being done at the moment, but rather indicate some modifications of institutional arrangements as well as suggest changes in some basic values which appear to guide the management of the water management process.

5.4.2 National Water Research Committee

If it is accepted that a national strategy is needed which integrates the talent and effort in the federal and provincial governments, universities, private sector, and interest groups, and if it is also accepted that water management in Canada involves many activities (data collection, research, planning, mediation, regulation, control, development), then the suggestion for a National Water Research Committee is appealing.

Creation of such a Committee would require significant federal initiative since the federal government is the one organization in a position to identify and to deal with the range of possible participants. The establishment of such a Committee would also be an explicit statement by the federal government that federal and national water strategies are not identical, that the provincial governments have an explicit role in shaping a national policy, and that water research should be linked to water management and development questions.

The National Water Research Committee would serve as a mechanism to identify and begin to coordinate research needs in various regions, sectors and professions/disciplines across the country. By bringing together individuals representing a variety of perspectives, it could begin efforts to ensure a balanced perspective in research, to strive for user responsiveness, and to ensure more anticipatory research. It also could identify opportunities for technology transfer as well as education and training.

Such a Committee would only be viable if it were given a mandate and the financial resources to ensure that it had some leverage to influence action. If it were created as only an advisory group, it would run the risk of being ignored by the vested interests which already create some of the stumbling blocks to more effective use of Canadian research talent. Such a Committee should be established with a "sunset" clause to ensure that its effectiveness would be reviewed regularly.

5.4.3 Federal Committee for Water Resources Research

Simultaneously with the creation of a National Water Research Committee, the federal government should establish a group to address the integration of federal water research efforts. At the moment, individual departments, ministries, services or directorates have research committees but no one group is responsible to review the water research effort for the entire federal system. The Interdepartmental Committee on Water does not, and cannot fulfill that role, since it does not meet frequently enough, does not have enough "researchers" among its membership, and too often serves primarily to relay information after decisions have been taken. Thus, whatever form such a federal research group might take, it is considered essential that a mechanism be created which can take an overview of federal water research activity in aggregate. Without a clearer sense of the ongoing nature of the overall federal effort related to water resources research, it will be difficult for the federal government to participate in any forum which might be established to develop a national strategy.

5.4.4 National Research Institutes

In order to realize economies of scale, the concept of centralized national research institutes is attractive. Several of these already have been created - the National Water Research Institute (Burlington), the National Hydrology Research Institute (in Ottawa and scheduled to move to Saskatoon) and the Freshwater Institute (Winnipeg). These were established to provide coordination among a number of organizations involved in research, efficiencies in provision of sophisticated

laboratory equipment, and interaction among scientists working in close proximity. These three characteristics are all real benefits. At the same time, however, this centralization has led investigators in some regions, especially Atlantic Canada, British Columbia and Alberta, to question the appropriateness of much of the research conducted in these institutes for the problems specific to their regions.

5.4.5 Regional Research Centres

To overcome the disadvantages associated with centralized, national research institutes, the alternative of regional research centres exists. This alternative could be developed in several ways. One would be to have a number of regional centres distributed across the country, each one focussing upon the issues and problems of its region. This option would ensure that regional needs were satisfied, but would lead to some duplication of effort for problems common to more than a single area. In addition, it would add expense if laboratory facilities were to be duplicated in the regional centres. Thus, the ability to respond to specific regional needs on an ongoing basis through regional centres would incur extra costs.

Another option would be to have smaller scale regional centres linked to national research institutes and/or a national council. In that manner, the research common to several regions could be conducted at the centralized national institutes where the sophisticated testing equipment could be concentrated. At the same time, regional centres would provide the flexibility to respond on a continuous basis to the needs in individual regions. In a modest form, this approach is in use, with, for example branch offices of the National Water Research Institute being located in Winnipeg and Vancouver. However, the small number of researchers and support staff in these branches makes it virtually impossible for them to address the range of problems in their regions. Furthermore, regions such as Atlantic Canada do not have a Branch and therefore are severely constrained.

Some of these regional centres could be designed to incorporate other related resource problems. For example, many erosion and water pollution problems have their root causes on the adjacent land resources. The regional centres thus could address water problems in relationship to associated land-based resources, or build explicit links with other existing regional research centres, such as those operated by Agriculture Canada. In that context, the following recommendation from the Standing Senate Committee in Agriculture, Fisheries and Forestry (1984, 13) deserves serious attention:

"That the Federal Government establish Soil and Water Conservation Institutes in Western, Central and Eastern Canada for the purpose of carrying out applied research."

In this regard, it is interesting to note that the Standing Senate Committee (1984, 14) urged a link between regional research activity and a national perspective, and recommended the formation of a "Council on Soil and Water Conservation" which would encourage improved coordination

and cooperation, aid in the prioritization of research and program demands, and gather and disseminate information on conservation.

5.5 LEVEL OF SUPPORT

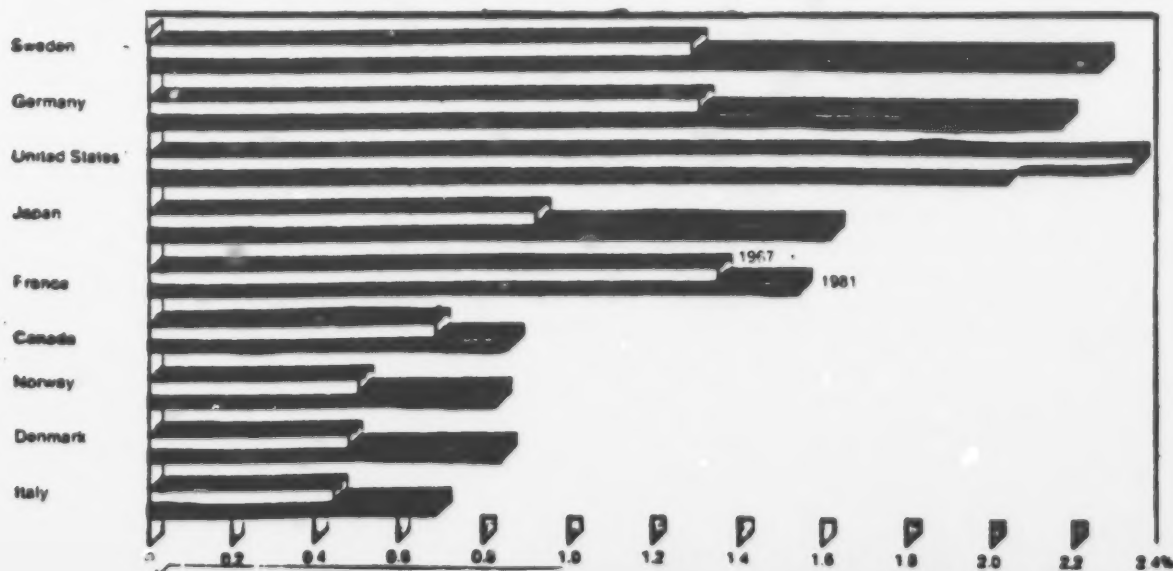
Determining the appropriate level of support for water resources research and related scientific activity is difficult since much of the output is not directly measurable in monetary terms. That problem being recognized, several general indicators can be examined. First, the general commitment to research in Canada can be reviewed by comparing Canadian investment in research and development against other countries. Second, at the federal level, it is possible to identify where research effort is concentrated. And third, it is possible to consider the investment made in water research in Canada and other countries.

One measure of commitment to research and development is the ratio of gross expenditures on research and development and gross domestic product. Using this indicator, Wright et al (1984, 3) concluded that "Canada ranks low on the scale of industrialized countries - far behind the U.S., Japan, Germany, and Sweden". They found that "in recent years, our R&D expenditures have fluctuated between .95 percent and 1.24 percent of GNP. The range in the countries mentioned above, is between two and three percent".

This modest rate of funding for research and development is further confirmed by Figure 5.1 in which Canada is in the middle rank of OECD member countries. However, what Figure 5.1 does not reveal is that most countries, particularly Sweden, Germany and Japan, have increased their research effort during the past 15 years while the Canadian effort has increased relatively little (Statistics Canada, 1984, 20).

Two conclusions may be drawn here. Compared to other industrialized countries, Canada provides relatively modest support for research and development. Furthermore, while other countries have been increasing their overall level of support, Canada has continued to maintain a much more modest level of support. In fields such as water,

Figure 5.1 Industrial R&D as a Percent of Domestic Product of Industry, Selected OECD Countries, 1967 and 1981



this situation makes it difficult for Canadian research on such topics as acid rain to be viewed as credible, since it can be pointed out that Canadian inventory and monitoring networks are inadequate.

Within the federal government, Table 5.1 reveals that the Department of Agriculture and the National Research Council are the main organizations in research and development, accounting for more than 40 percent of the \$1 billion total (Statistics Canada, 1983, 23). From the 1984-1985 federal estimates in which it was identified that the Department of Agriculture allocated \$2.5 million to water research, it can be seen that water receives about 1 percent of that organization's research funds.

Table 5.2 shows by 1981 that almost half of the research and development conducted by the federal government was performed in the National Capital Region, and that over two-thirds of research and development expenditures occur in the central provinces of Ontario and Quebec. While these figures are for all federal research and development activity, they tend to confirm the earlier observation that there has been a trend towards centralization of research effort.

Provincial research and development expenditures are primarily accounted for by provincial agencies and provincial research councils or foundations. Except for Newfoundland and Prince Edward Island, each province has a research council or foundation. Table 5.3 presents estimates of regional expenditures during 1981. Just under 40 percent of the provincial expenditures occurred in Ontario, and about 60 percent occurs in Ontario and Quebec. With the notable exception of Alberta, Table 5.3 reinforces an overall pattern of research and development activity concentrated in central Canada.

Regarding levels of support for water resources research in Canada, Lefevre (1984, 5) indicated that total funding increased to \$52 million in 1979 from \$20 million (1979 dollars) in 1966. This increase in 250 percent from 1966 to 1979 fell far short of the recommendations by Bruce and Maasland (1968) who called for an increase of 20% per year.

By 1983, the overall funding for water research in Canada was about \$56 million; when this is compared with the \$75 million (1983 dollars) expenditure on research in 1979, these results show a 25 percent reduction from 1979 levels.

Comparisons with other nations' support for water resources research would place Canadian figures in context. Unfortunately, most of the countries which were contacted with a request for such information could not provide the desired data. In many cases, the negative response reflected the absence of any organization with a mandate to take a national overview of water resources research. Nevertheless, some data are available.

Table 5.1 Expenditures on R&D Performed Within
the Federal Government, by Department

Department	1976	1977	1978	1979	1980	1981	1982p	1983p
	millions of dollars							
Agriculture	107	115	126	143	153	178	199	228
Atomic Energy of Canada Ltd.	60	57	68	64	69	82	96	106
Energy, Mines & Resources	48	55	66	64	82	107	132	135
Environment	106	106	60	60	77	84	102	100
Fisheries and Oceans	---	---	67	67	75	85	92	97
National Defence	54	62	61	59	72	78	88	104
National Research Council	81	89	102	112	129	152	191	208
Other	53	72	86	77	80	99	116	117
Total	509	556	636	646	737	865	1,016	1,095

Source: Statistics Canada (1983, 23)

p = predicted

Note - while it appears that beginning in 1978 Environment experienced a decrease in expenditures on R&D, that pattern reflects the splitting away of Fisheries and Oceans from Environment.

Table 5.2 Federal Performance of R&D, by Region, 1981

Province and Region	Millions of Dollars	Percent of Total
British Columbia	45	5
Alberta	46	5
Saskatchewan	24	3
Manitoba	65	7
Western Provinces -	180	21
Ontario	121	14
National Capital Region	417	48
Quebec	64	7
Central Provinces -	602	70
New Brunswick	21	2
Nova Scotia	44	5
Prince Edward Island	5	1
Newfoundland	13	1
Atlantic Provinces -	83	10

Source: Statistic Canada (1983, 23)

Table 5.3 Sources of Funds for R&D Performed Within the Provincial Government Sector, 1981

Province	Source of Funds (millions of dollars)			Total
	Governments	Business Enterprise	Foreign	
Atlantic Provinces	3	1	---	4
Quebec	26	2	---	28
Ontario	46	5	1	52
Manitoba & Saskatchewan	7	1	---	8
Alberta	30	1	---	31
British Columbia	13	1	---	14
Canada	124	11	1	137

Source: Statistics Canada (1983, 24)

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Comparisons with other nations' support for water resources research would place Canadian figures in context. Unfortunately, most of the countries which were contacted with a request for such information could not provide the desired data. In many cases, the negative response reflected the absence of any organization with a mandate to take a national overview of water resources research. Nevertheless, some data are available.

The Australian Water Resources Council (1982, 82) assembled some data regarding expenditure in selected countries on water research as a percentage of the annual capital expenditure on water developments. The results were:

Australia	1.4%
United Kingdom	2.2%
Canada	2.8%
South Africa	2.8%
United States	4.0%

As with indicators for research in general, Canada falls in the "middle ground" regarding its support for water resources research.

The available evidence indicates that Canada has taken a "middle of the road" position in supporting research in general, and water research in particular. Of concern, however, are the reductions in research support to Environment Canada over a period in which the support for research in other federal departments has grown. Those reductions are illustrated by the decrease by three-quarters of the funds in the IWD Water Resources Research Support Program.

The Australian Water Resources Council (1982, 7) recommended the establishment of a "National Water Research Council" to provide advice to the government regarding "national research goals, needs and priorities and the development and management of a comprehensive national water research and technology transfer program". In contrast, in September of 1983 the British government dissolved its National Water Council and in September 1981 President Reagan signed on Executive Order which terminated the American Water Resources Council. Both of these organizations were perceived as not directly accountable or responsible for their actions, which made them dispensable. At the same time, these executive decisions also removed the organizations which had an overview of the national water scenes in their respective countries.

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Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The previous chapters have described the nature and extent of effort in water resources research in Canada, have identified substantive and managerial issues, problems and opportunities, and have considered the financial implications of present and future research efforts. In this chapter, the major conclusions and recommendations are presented. They all emerge from the findings presented in Chapters 1.0 through 5.0.

6.2 A FEDERAL ROLE IN WATER RESOURCES RESEARCH

Strong support exists in the country for a continued role by the Federal Government in water resources research, particularly regarding problems of an inter-jurisdictional nature. A federal role is not identical with a national water research strategy. Therefore, if the diverse research talent in the country is to be effectively mobilized, a national research strategy must be identified. For the Federal Government to participate in a national strategy, it is imperative that it clearly define its role.

6.3 THE EXTENT AND NATURE OF THE FEDERAL ROLE

The current federal role in water resources research is extremely large. The Federal Government, through its various agencies, presently provides 73 percent of the funds for water research in the country. Furthermore, Federal Government agencies spend 51 percent of the water resources research dollars. These figures demonstrate that Federal Government agencies collectively comprise the main participant in water research both as a 'doer' and as a 'facilitator'.

RECOMMENDATION 1:

THE FEDERAL GOVERNMENT SHOULD CONTINUE TO BE A MAJOR PARTICIPANT IN WATER RESOURCES RESEARCH IN CANADA. HOWEVER, TO MORE EFFECTIVELY USE THE RESEARCH TALENT IN THE COUNTRY THERE SHOULD BE AN INCREASING ROLE FOR RESEARCHERS BASED IN THE UNIVERSITY AND PRIVATE SECTOR (SEE RECOMMENDATIONS 8 AND 9).

6.4 MAJOR MANAGEMENT NEEDS

6.4.1 Coordination

Given the diverse array of research activity at the federal, provincial, private sector and university levels, a very important need is to achieve a systematic coordination of the research effort and to relate research to management needs. The most appropriate approach to develop a national strategy would be to create a National Water Research Committee. Comprised of representatives from the different groups involved in research, it would strive to minimize duplication of facilities and effort across the country, ensure a balance was realized between national and regional research problems, facilitate

communication within the research community and encourage liaison between researchers and managers. The committee would have to be allocated sufficient funds and authority so that it could influence research activity. Without sufficient resources, a great weakness of such a committee is that it could be ignored by the existing line agencies. The Research Committee would be created with a "sunset" clause to ensure that its effectiveness is assessed on a regular basis. This Research Committee could become the first step toward a more, all encompassing, Council which would be responsible for research, planning, management, and development.

RECOMMENDATION 2:

THE FEDERAL GOVERNMENT SHOULD TAKE THE LEAD IN ESTABLISHING THE NATIONAL WATER RESEARCH COMMITTEE, WHOSE OVERRIDING GOAL SHOULD BE TO DEVELOP A NATIONAL STRATEGY FOR WATER RESOURCES RESEARCH. THE IWD SHOULD PROVIDE THE SECRETARIAT FOR THE COMMITTEE WHICH WOULD HAVE A MAXIMUM MEMBERSHIP OF FIFTEEN INDIVIDUALS (SIX FEDERAL, THREE PROVINCIAL, THREE UNIVERSITY AND THREE PRIVATE SECTOR).

RECOMMENDATION 3:

THE FEDERAL GOVERNMENT SHOULD ESTABLISH A FEDERAL COMMITTEE FOR WATER RESOURCES RESEARCH WHOSE PRIMARY GOAL SHOULD BE TO DEVELOP A FEDERAL STRATEGY. THE COMMITTEE MEMBERSHIP SHOULD INCORPORATE RESEARCHERS AND MANAGERS FROM FEDERAL AGENCIES WITH A SIGNIFICANT ROLE IN WATER RESEARCH. THE MEMBERSHIP SHOULD REPRESENT BOTH HEADQUARTERS AND REGIONAL CONCERNS.

6.4.2 Efficiency

In the interests of efficiency there has been a trend towards centralization of research effort. There have been at least two major benefits from centralization. First, scale economies have been realized in purchases and operations of sophisticated and expensive laboratory equipment. Second, having large groups of scientists in proximity to each other has provided the critical mass of energy and talent so often necessary for scientific breakthroughs. For these two reasons the centralization trend can be supported.

At the same time, further potential advantages from centralization exist. While on paper it appears feasible for investigators from universities and the private sector to use the sophisticated equipment in government laboratories, in practise such cooperative use has occurred only rarely. Thus, there seems to be considerable opportunity to make some of the sophisticated testing equipment in the federal laboratories available to the larger research community.

On the other hand, there have been major costs associated with centralization. For those regions which do not have one of the centralized research facilities, there is a real danger that their regional needs get overlooked or ignored. To overcome this weakness it would be appropriate to have more regional branches or centers affiliated with the national research centers distributed across the country. At the moment there are several such regional operations. If more regional centers were to be established, the first priority

should be to create such a center in the Atlantic Region. Atlantic Canada seems to have been inadequately served by national research efforts. British Columbia should be the next priority area concerning a regional centre.

RECOMMENDATION 4:

THE EXISTING NATIONAL RESEARCH INSTITUTES SHOULD BE CONTINUED BUT GREATER PROVISION SHOULD BE DEVELOPED FOR ACCESS TO THEIR SOPHISTICATED EQUIPMENT BY OUTSIDE USERS.

RECOMMENDATION 5:

TO ENSURE THAT REGIONAL RESEARCH NEEDS ARE ADDRESSED, MORE REGIONAL RESEARCH CENTRES SHOULD BE ESTABLISHED. ATLANTIC CANADA SHOULD BE THE FIRST PRIORITY TO RECEIVE A RESEARCH CENTRE.

6.4.3 Anticipatory Research

Funding sources of the Federal Government have increasingly shifted to more mission-oriented research effort. Thus, directions of research have been increasingly influenced by the funding source. Such an approach seems reasonable in times of restraint but freedom and innovation in research may suffer if it is too fully directed. As well, with the current system there is a tendency to fund 'safe' science, where results are essentially guaranteed. However, major issues related to water resources usually are long term in nature and seldom are resolved in less than twenty-five years from the time that they are first recognized as problems or opportunities. Consequently, research must not be 'packaged' as short term tasks to be distributed across the country.

In response to these problems, some portion of the overall research budget should be targeted at innovative and unrestricted water research. A mechanism to allocate such funds could be the National Water Research Committee with a mandate to include future-oriented, innovative research. The mandate of the Committee should specifically include allowance for failure of some research to produce 'positive' results, since the concern of this Committee would be to stimulate truly innovative research that might provide significant breakthroughs.

RECOMMENDATION 6:

A PROPORTION OF THE RESEARCH BUDGETS OF THE NATIONAL WATER RESEARCH COMMITTEE, THE NATIONAL INSTITUTES AND REGIONAL CENTRES SHOULD BE DESIGNATED TO SUPPORT RESEARCH OF A HIGH RISK AND LONG TERM NATURE.

6.4.4 User Responsiveness

A frequent concern is that managers or users and researchers do not consult with each other regarding research needs and priorities. As a result, many times it has been suggested that a mechanism is needed to facilitate such dialogue. The National Water Research Committee if composed of individuals not just from different levels of government, universities and the private sector but also from both managers and researchers, should be able to improve the responsiveness of the research to the needs of users or managers.

If the membership on the committee also included representatives from different regions in the country, then it also should be possible to ensure that distinctive regional problems get fair consideration.

RECOMMENDATION 7:

TO ENSURE THAT THE WATER RESEARCH ACTIVITY RESPONDS TO THE NEEDS OF WATER MANAGERS AND USERS, THE VARIOUS RESEARCH COMMITTEES, INSTITUTES AND CENTRES SHOULD HAVE A MANAGEMENT COMMITTEE INVOLVING RESEARCHERS, MANAGERS AND USERS.

6.4.5 Balanced Perspectives

There appears to be a major need for research activity that integrates findings and understanding generated from research in a variety of disciplines and professions. Unfortunately, many researchers report having significant difficulties in obtaining funding for such interdisciplinary research especially from NSERC and SSHRC.

A frequent observation made to the Inquiry was that there is a need for a larger amount of social science research effort in the water field. It should be recognized that social scientists can apply to the Social Sciences and Humanities Research Council of Canada to obtain research funding. To date, a very small number of social scientists working in the water field have regularly received research awards from SSHRC. Furthermore, SSHRC has received very modest increases in its funding programs, so that major new initiatives in water resources research are highly unlikely, if the historical pattern of funding to SSHRC is maintained.

The Federal Government could take the initiative to encourage or stimulate social science research by identifying more problem areas which require analysis by social sciences and by establishing funds designated to support social sciences research.

Engineering, physical and life scientists have generated substantial funding through the Natural Science and Engineering Research Council. All university-based investigators, however, have expressed disappointment at the modest funding provided for water research through the Inland Waters Directorate subvention program. To achieve a variety of perspectives pertinent to water resources problems, the Federal Government could show much more leadership by increasing the research funding to non Federal Government investigators.

RECOMMENDATION 8:

NSERC AND SSHRC SHOULD REVIEW EXISTING PROCEDURES FOR ASSESSING INTERDISCIPLINARY RESEARCH PROPOSALS IN ORDER TO ENSURE A MORE EFFECTIVE REVIEW OF SUCH PROPOSALS.

RECOMMENDATION 9:

TO ENCOURAGE MORE SOCIAL SCIENCE RESEARCH IN THE WATER FIELD, A GREATER LEVEL OF FUNDING SHOULD BE PROVIDED TO SSHRC FROM THE FEDERAL GOVERNMENT.

RECOMMENDATION 10:

THE WATER RESOURCES RESEARCH SUPPORT PROGRAM SHOULD RECEIVE INCREASED FUNDING AND SOME OF THIS INCREASED FUNDING SHOULD BE SET ASIDE TO SUPPORT SOCIAL SCIENCE RESEARCH.

6.5 COMMUNICATION

The Federal Government has developed an extensive data management system to support water research activity. Given the array of potential users, it is not clear how effectively the needs of the researchers across the country have been serviced by these systems. While these systems provide an inventory of current reports and information, they do not provide a systematic listing of ongoing research activity (investigation, topic, level of support, time-frame).

If coordination of research effort is one of the most important priorities for the future, communication of research results from the investigators to the managers and users is also very much in need of improvement. A major problem appears to be that researchers publish in journals which are primarily read by other researchers, rather than managers or users.

Clearly, there is need for outlets for research whose main target is other researchers. In addition, it is not desirable to have a proliferation of journals and periodicals. However, some of the existing journals, such as the Canadian Water Resources Journal or the Water Pollution Research Journal of Canada, might be encouraged to develop two major sections. One section could contain research reports oriented primarily towards other researchers. The other section might contain articles focussed more towards the needs of users and managers. If this were to be done, the journals would incur extra publication costs. Therefore, in the interests of furthering communication between researchers and managers, the Federal Government might provide some funding to allow this modification.

RECOMMENDATION 11:

GIVEN THE DEVELOPMENT OF THE DIFFERENT DATA MANAGEMENT SYSTEMS, IT IS RECOMMENDED THAT A SYSTEMATIC REVIEW OF THESE SYSTEMS BE CONDUCTED BY THE FEDERAL GOVERNMENT TO DETERMINE THEIR EFFECTIVENESS AND EFFICIENCY.

RECOMMENDATION 12:

THE FEDERAL GOVERNMENT SHOULD DEVELOP AN INVENTORY OF ONGOING WATER RESOURCES RESEARCH PROJECTS WHICH WOULD BE ACCESSIBLE ON AN ON-LINE BASIS TO RESEARCHERS IN THE FEDERAL, PROVINCIAL, UNIVERSITY AND PRIVATE SECTORS.

RECOMMENDATION 13:

TO FOSTER COMMUNICATION BETWEEN RESEARCHERS AND MANAGERS, THE FEDERAL GOVERNMENT SHOULD PROVIDE FUNDING TO SELECTED CANADIAN JOURNALS IN THE WATER FIELD TO ASSIST THEM IN INCLUDING MORE REPORTS PERTINENT TO THE NEEDS OF MANAGERS AND USERS.

6.6 RETRAINING AND EDUCATION

One of the characteristics of innovative and outstanding researchers is the ability to keep abreast of the most recent concepts, methods and techniques. Traditionally, much of this upgrading and re-education has occurred through the interaction between recently-hired junior investigators and their more senior experienced colleagues, or through people exchanging views and experiences at professional meetings. In times of restraint, when very few new scientists are being hired and when substantial restrictions are placed on travel to conferences, these traditional mechanisms do not work. This must be recognized. If the Federal Government is serious about supporting retraining and education, then sufficient resources must be allocated to either hire new staff, facilitate participation in professional meetings or accommodate sabbaticals or other forms of exchanges by federal scientists with their counterparts in other institutions.

RECOMMENDATION 14:

THE FEDERAL GOVERNMENT SHOULD DEVELOP A SYSTEM OF SABBATICALS AND SHORT-TERM LEAVES TO ENCOURAGE FEDERAL RESEARCH SCIENTISTS TO BROADEN THEIR EXPERIENCES AND EXPOSE THEM TO THINKING AND PROCESSES IN NON-FEDERAL INSTITUTIONS.

RECOMMENDATION 15:

THE FEDERAL GOVERNMENT SHOULD ASSIST THE CONTINUING EDUCATION OF PROFESSIONALS BY PROMOTING OPPORTUNITIES FOR ATTENDANCE AT SHORT COURSES. SERIOUS CONSIDERATION SHOULD BE GIVEN TO ACCOMPLISHING THIS BY FOLLOWING THE EPA EXAMPLE WHERE SPEAKERS AT SHORT COURSES ARE MOVED TO VARIOUS LOCATIONS AND ONLY VERY MODEST FEES ARE CHARGED, SO AS TO ASSIST THE OPPORTUNITY FOR ATTENDANCE.

RECOMMENDATION 16:

THE FEDERAL GOVERNMENT SHOULD EXPLORE OPPORTUNITIES FOR SCHOLARSHIPS TO ASSIST STUDY IN WATER RESOURCES RESEARCH. THE RECENTLY INITIATED PROGRAM BEING USED BY FEARO COULD BE USED AS A MODEL FOR A SIMILAR PROGRAM IN THE WATER FIELD.

6.7 FUTURE FUNDING LEVELS

Funding levels of water resources research in recent years have not kept pace with inflation. Current funding levels represent only 74 percent of 1979 research efforts. This represents a significant decrease in research effort. In the interim, new problems have emerged in the water field.

As a consequence of the decrease in research funding from 1979, an even greater shortfall from the recommendations regarding needs for increased funding as presented in the Bruce and Maasland report in 1968 has occurred.

RECOMMENDATION 17:

GIVEN THE 25 PERCENT REDUCTION IN SUPPORT FOR WATER RESOURCES RESEARCH SINCE 1979, INCREASES IN FUNDING OVER THE NEXT FIVE YEARS ABOVE THE RATE OF INFLATION SHOULD BE INSTITUTED. AN ANNUAL INCREASE OF 10 TO 12 PERCENT COULD BE A TARGET, AT A LEVEL OF 5 PERCENT ABOVE THE RATE OF INFLATION.

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APPENDIX I

QUESTIONNAIRE



Waterloo, Ontario, Canada
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Faculty of Engineering
Department of Civil Engineering
519/885-1211

August 1, 1984

The Science Council of Canada and the Inquiry on Federal Water Policy are the co-sponsors of our study on the status of water resources research in Canada. Attached is a letter confirming this sponsorship. The objectives of the study are:

- (1) to provide an updated inventory of water research activities in Canada for 1983 or April 1983-March 1984, whichever is appropriate for your organization, identifying effort in different categories of research and among federal, provincial, university and private sectors,
- (2) to identify future research needs and priorities, and,
- (3) to evaluate federal research programs in terms of their capacity to respond to changing priorities for water resources research, co-ordination and management in Canada.

Sources being contacted for this information are individuals and organizations across the country involved in water resources research.

We would appreciate your sending us information about the water resources research in your department.

Enclosed are two questionnaires. The Reporting Unit questionnaire is used to collect overall cost and manpower information. The Project questionnaire is used to collect information describing individual research projects. These questionnaires should be distributed to the individuals responsible for particular research projects.

We are aware that Bruce and Maasland published a report for the Science Council of Canada on the status of water resources in Canada in 1968, and that in 1979 Environment Canada updated their inventory. Many people across the country took considerable time to provide data essential for these studies. Our assignment in directing this third study involves submission of a report in early 1985, both updating the inventory and identifying future issues, opportunities, constraints and strategies relative to water resources research in Canada. The results of this inquiry will be used by the Inquiry on Federal Water Policy.

Although we are requesting the names of researchers, that information will be used only to facilitate categorizing and processing. Responses will be treated in confidence, and no individual will be identified by name in the report.

For responses from your department to be taken fully into account, we need to receive the completed questionnaire by not later than September 14, 1984. As a result, we hope that you will distribute them as quickly as possible to your researchers, and make them aware of the importance of receiving their input.

If you have any questions, please do not hesitate to contact either of us. For purposes of return correspondence, please direct to:

Professor Edward McBean
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario, N2L 3G1

Yours sincerely,

Yours sincerely,

Bruce Mitchell,
Professor of Geography
(519) 885-1211 (Ext. 3064)

Edward McBean,
Professor of Civil Engineering
(519) 885-1211 (Ext. 3349)



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THE SCIENCE COUNCIL OF CANADA AND THE
INQUIRY ON FEDERAL WATER POLICY

WATER RESEARCH INVESTIGATION

The Science Council of Canada undertook a major study of water resources research in the 1960s which led to publication in 1968 of Special Study No. 5 by Bruce and Maasland, "Water Resources Research in Canada", and Council Report No. 3, "A Major Program of Water Resource Research in Canada." New issues are now emerging (e.g. toxic chemical pollution, interbasin transfers), leading to a need to reassess water research needs between now and the year 2000. Environment Canada convened several workshops a few years ago to examine a number of the relevant issues but did not address the question of where water research should be heading in the future. Science Council has given some consideration to further work in the area.

The Minister of the Environment recently established, with Cabinet approval, a three-member Inquiry on Federal Water Policy, chaired by Dr. Peter Pearse. The Inquiry has the mandate to consult broadly with Canadians and their governments; to substantiate the nature of emerging issues; to assess available supplies and future requirements for the conservation and use of water; and to "assess the needs for, and nature of, additional scientific and research expertise in water management in Canada."

Because of a common interest in future water research activities, the Inquiry and Science Council have agreed to jointly sponsor work in this area and have entered into a contract with Professors Edward McBean and Bruce Mitchell of the University of Waterloo to undertake the project.

The objectives of this joint project are:

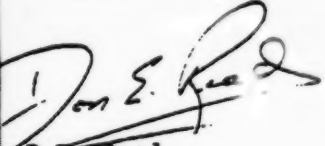
1. To update the inventory of water research activities, using the Science Council reports of 1968 and Environment Canada paper of 1979 as bases, identifying changes in effort among research categories and changes in effort and funding among federal, provincial, university and private sectors.
2. To identify future research needs and priorities, in consideration both of current trends and emerging water issues as substantiated by the Inquiry on Federal Policy.

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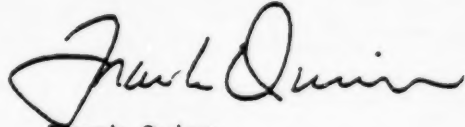
3. To evaluate federal research programs in terms of their capacity to respond to changing priorities for water resources research, co-ordination and management in Canada.

Science Council of Canada

Inquiry on Federal Water Policy


Don E. Read
Science Adviser

July 13, 1984


Frank Quinn
Director of Research

WATER RESOURCES RESEARCH CATEGORIES

305. NATURE OF WATER

Category 100 deals with fundamental research on the water substance.

301. Properties of water — Study of the physical and chemical properties of water, including its thermodynamic behavior in its various states.

302. Aqueous solutions and suspensions — Study of the effects of various solutes on the properties of water; surface interactions; colloidal suspensions.

306. WATER CYCLE

Category 200 covers research on the natural processes involving water. It is an essential supporting effort to applied problems in water management.

303. General. Including studies involving two or more phases of the water cycle such as hydrologic models; rainfall-runoff relations; surface and ground-water relationships; watershed studies; geomorphology.

304. Precipitation. Including investigation of spatial and temporal variations of precipitation; synoptic effects; time trends; climatic; problems maximum precipitation; structure of storms; quantitative precipitation forecasting.

305. Snow and ice. Including studies of the occurrence and thermodynamics of water in the solid state in nature; spatial variations of snow and frost; formation of ice; break-up of river and lake ice; glaciers; ice forms; permafrost and its effects on groundwater and the water cycle.

306. Evaporation and transpiration. Including investigation of the process of evaporation from lakes, soil, and snow and of the transpiration process in plants; methods of estimating actual evapotranspiration; energy balance.

307. Streamflow. Including: mechanism of flow in streams; flood routing; base storage; space and time variations (including high and low-flow frequency); droughts; floods.

308. Groundwater. Including: study of the mechanics of groundwater movement; multilayer systems; sources of natural recharge; mechanics of flow to wells and drains; subsidence; properties of aquifers; saline water intrusion in coastal aquifers.

309. Water in soils. Including: infiltration; movement and storage of water in the zone of aeration, including soil.

310. Lakes. Including: hydrologic, hydrochemical, and thermal regimes of lakes; water level fluctuations; currents and waves.

311. Water and plants. Including: role of plants in hydrologic cycle; water requirements of plants; microclimate of precipitation.

312. Erosion and sedimentation. Including: studies of the erosion process; prediction of sediment yield; sedimentation in lakes and reservoirs; stream erosion; sediment transport; river-bed evaluation.

313. Chemical processes. Including: chemical interactions between water and its natural environment; chemistry of precipitation.

314. Estuarine problems. Including: special problems of the estuarine environment; effect of tides on flow and stage; dependence of sediments; sea water intrusion in coastal aquifers.

300. WATER SUPPLY AUGMENTATION AND CONSERVATION

As water use increases we must pay increasing attention to methods for augmenting and conserving available supplies. Research in Category 300 is largely applied research directed to this problem area.

301. Saline water conversion — Research and development related to methods of desalting sea water and brackish water.

302. Water yield enhancement — Increasing streamflow or improving its distribution through land management; water harvesting from upland areas; phreatophyte culture; reservoir evaporation suppression.

303. Use of water of impaired quality — Research on methods of agriculture; use of water of high salinity; use of poor quality water in industry; crop tolerance to salinity.

304. Conservation in domestic use — Methods for reducing domestic water needs without impairment of service.

305. Conservation in industry — Reduction in both consumption and discharge requirements for industry.

306. Conservation in agriculture — More efficient irrigation practices; chemical control of evaporation and transpiration; lower water use plants; optimum use of soil moisture, etc.

307. Weather Modification — Artificial simulation of precipitation; climate modification by changes in cloud and water balance, etc.

300. WATER QUANTITY MANAGEMENT AND CONTROL

Category 400 includes research directed to the management of water, including its distribution, and the effects of related activities on water.

401. Control of water on the land — Effects of land management on runoff, land drainage; pollution, etc.

402. Groundwater management — Artificial recharge; conjunctive operation; return to storage.

403. Effects of man's related activities on water — Impact of urbanization, highway, logging, etc., on water yield and flow rate.

500. WATER QUALITY MANAGEMENT AND PROTECTION
As increasing population increases the waste and other pollutants entering our water supplies, Category 500 deals with methods of identifying, controlling and controlling the pollutants.

501. Identification of pollutants — Techniques of identification of physical, chemical and biological pollutants; residual amounts of character and strength of wastes.

502. Sources and fate of pollution — Determination of the sources of pollutants in water — the nature of the pollution from various sources; path of pollution from source to stream or groundwater; prediction of pollution concentrations including prediction by means of mathematical models; effects of man cover on dissolved oxygen and other pollutants in streams and lakes, etc.

503. Effects of pollution — Definition of the effect of pollutants, singly and in combination, on man, aquatic life, agriculture and industry under conditions of assumed use; eutrophication; influence of prolonged oil-cover on effects of pollutants, etc.

504. Waste treatment processes — Research to improve conventional treatment processes to gain efficiency or reduce cost; processes to treat new types of waste; advanced treatment methods for more complete removal of pollutants including purification for direct reuse.

505. Ultimate disposal of wastes — Disposal of residual material removed from water and sewage during the treatment process; disposal of waste sludge; underground waste disposal.

506. Water treatment — Development of more efficient and economical methods of cleaning water suitable for domestic or industrial use.

507. Water quality control — Research on methods to control stream and reservoir water quality such as flow augmentation; stream and reservoir aeration; control of natural pollution; control of pollutants from pesticides and agricultural chemicals; control of acid mine drainage; control of erosion and sedimentation, etc.

600. ECONOMIC, SOCIAL AND INSTITUTIONAL ASPECTS
The problems of achieving an optimal plan of water development are becoming increasingly complex. Category 600 covers research directed to determining the best way to plan the appropriate criteria for planning and the nature of the economic, legal and institutional aspects of the planning process.

601. Planning — Application of systems analysis to project planning; treatment of uncertainty; preliminary studies; non-structural alternatives.

602. Evaluation process — Development of methods, concepts and criteria for evaluating project benefits, discount rate; project life; methods for economic, social and technological projections; reliability of projections; remarks on the value of water in various uses, etc.

603. Cost allocation, cost sharing, pricing/replacement — Research on methods of calculating replacement and establishing prices for vendible products; techniques of cost allocation, cost sharing; pricing and replacement policy.

604. Water requirements — Research on the water quantity and quality requirements of various uses.

605. Water law — Studies of provincial and federal water law leaving to changes and additions which will encourage greater efficiency in water use.

606. Institutional aspects — Investigation of institutional structures and constraints which influence decisions on water at all levels of government; case studies; jurisdictional problems.

607. Sociological and psychological aspects — Attitudes to use of water; perception of responsibility.

608. Ecologic impact of water development — Effects of water management operations on overall ecology, including human ecology, of the area. Excludes effect of pollution under 503.

700. RESOURCES DATA

Planning and management of our water resources require information. Category 700 includes research oriented to data needs and the most efficient methods of meeting these needs. Basic data collection in itself is not basic considered research, but studies of ways to improve data collection are included.

701. Network design — Studies of data requirements and of the most effective methods of collecting the data.

702. Data acquisition — Research on new and improved instruments and techniques for collection of water resource data, including data on water use and water and climate change; measuring equipment.

703. Evaluation, processing and publication — Studies of effective methods of processing data, form and nature of published data; maps of data.

800. ENGINEERING WORKS

To implement water development plans require engineering works. Category 800 describes research on design, materials and construction which is specifically useful to water management. Works relevant to a single specific goal, such as water treatment or floodabatement, are included elsewhere if an appropriate category exists.

801. Specifications and Design — Studies of functional requirements of water structures; research leading to improved design of dams, canals, pipelines, locks, sluiceways and other works required for water resource development.

802. Materials — Research to improve existing structural materials and to develop new materials for use in water control and conveyance structures.

803. Operations — Research on efficient operating procedures, and maintenance procedures for water control works.

900. Environmental Management and Protection

ASSESSMENT OF RESEARCH NEEDS

As with all questionnaires, their distribution must be limited. However, from the responses we must extrapolate the information to characterize the national scene of water resources research in Canada. This is not a task that is simple, nor taken lightly, since there are severe dangers of both omission and duplication. As a result, when completing the questionnaire, please keep in mind:

- (i) The scope of research you are reporting for:
 - e.g. (a) you as an individual _____
 - (b) the branch, division, or unit in which you work _____
 - (c) other (specify) _____
 - (ii) The questionnaire is being completed by an array of people with diverse backgrounds, thereby implying some questions may be more directly relevant to your concerns than are others.
 - (iii) Please use the reverse side and/or append additional pages as required.
1. In your view, what are the needs and priorities for water resources research in Canada between now and the year 2000? What issues are likely to be most important in the 1990's, and what should we be doing now in research to be ready to address them in the 1990's?
 2. What changes should be made to improve the capacity of federal research programs to respond to changing priorities for water resources research? How can/should flexibility be "built in" to the management of research programs to ensure that we address the issues of the future as well as of the present?
 3. What changes should be made to improve the coordination of federal programs in water resources research related to various research activities amongst different federal departments as well as in provincial governments, universities, and the private sector?
 4. Are results from water research in Canada being effectively applied to the resolution of practical problems? If not, what are the main obstacles to effective application? What should/could be done to improve the use of results from water research in the 1990's to resolve practical problems?
 5. In the planning and conduct of water resources research, what proportion of your research time in 1983 or 83/84 has been allocated to the following categories?

	Mission-oriented	Unconstrained by mandate or mission
pure/basic research		
applied research		

What, in your estimation, would be an appropriate mix of effort at a national level during the 1990's?

	Mission oriented	Unconstrained by mandate or mission
pure/basic research		
applied research		
		100

Comments:

6. Water problems cross disciplinary and professional boundaries, yet the structure of most government agencies and universities often mitigates against either interdisciplinary research or the integration of research results from various fields.
 - (a) What percentage of your research work has been conducted in group efforts? _____
 - (b) When you have been involved in group research, have the other individuals had a disciplinary or professional background similar to yours? _____
 - (c) What action could the federal government take to encourage more interdisciplinary research in the future?
7. In a country as large and diverse as Canada, regional water resources issues may be quite different. What action could be taken to ensure that federal water resources research programs in the future respond more effectively to different regional needs?
8. What are the major constraints - shortage of funds, your time, shortage of professional personnel, shortage of technicians, inadequate space, inadequate equipment, or other (?) - to a larger role in water resources research in your organization? Please prioritize and comment briefly.
9. If your work has resulted in published papers, what percentage have been published in Canadian journals? _____
 What are the reasons for your decisions for publishing in other than Canadian journals, when you have? What changes are needed to encourage you to publish more of your papers in Canadian journals in the future?
10. In your own research when considering the role of the federal government in water research in Canada, what are the most important issues and needs requiring attention in the years ahead? Please prioritize.

What issues and needs receiving considerable attention over the last decade might, in your estimation, receive diminished attention in the next two decades?

Other comments/suggestions:

The following questions are intended for university-related people, although we welcome comments from any interested parties.

1. Should professors be allowed to "buy out" some of their teaching tasks (where some of the research money is used to hire other individuals to assume some (but not all) of the teaching responsibilities?)

2. How many proposals did you write and, of these, how many were funded during the reporting period? What was the major reason you prepared the number you did, and not more?

3. If you have a designated centre for water resources research at your university, please provide
 - (a) its name: _____
 - (b) date which it was established: _____
 - (c) areas/fields of water resources research in which it has specialized: _____
 - (d) number of employees in 1983: _____
 - (e) status (is the centre a formal entity?) _____

4. From which sources did you receive funds to support graduate students (do not include scholarship-supported individuals) working in the field of water resources research?

NSERC	SSHRC	NRC	CMHC	ENV. CANADA	OTHER FEDERAL	PROVINCIAL (SPECIFY)	PRIVATE SECTOR	OTHER
_____	_____	_____	_____	IWD	(SPECIFY)	_____	(SPECIFY)	_____

_____ SUM
= 100%

Your efforts in completing the questionnaire are greatly appreciated.

Please return completed questionnaires to:

Professor Edward McBean
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario, N2L 3G1

PROJECT QUESTIONNAIRE

1. Institution or Agency
(Name and Address)
2. Reporting Year
Note: The reporting period should be one year in length. From
either calendar year 1983, or where more convenient, Month Year
the closest fiscal year (e.g., for federal agencies To
FY 1983-4). Month Year

PROJECT DATA

Note: Questions 3-13 below should be answered for each project active in the reporting year. This return provides space for up to three projects. For additional projects, either use additional forms or attach sheets with question numbers and answers.

3.	Project Title (twenty words or less).....			
	Brief description of purpose.....			
3.	Project Title (twenty words or less).....			
	Brief description of purpose.....			
3.	Project Title (twenty words or less).....			
	Brief Description of purpose.....			
4.	Sub-category of research Note: Enter the most applicable from categories on attached list			
5.	Name of project leader	Family		
		Given		
6.	Work on reported project in reporting year. Enter man years (nearest 0.1 man year) for each indicated classification.	Doctor		
		Master		
		Bachelor		
		Undergraduates and post-graduate assistants		
		Technicians		
7.	Was project requested by another agency? <u>Check</u>	Yes	No	Yes No Yes No
8.	Was project co-operative with another agency during the reporting period? Note: A co-operative project is one in which two or more institutions or agencies are actively engaged in the research, or a second institution provides instruments and technical advice. If a second institution simply supports the project financially, the project would not be called co-operative <u>Check</u>	Yes	No	Yes No Yes No Yes No
9.	Duration of Project. This project commenced in	Month		
		Year	19....	19.... 19....
	and is expected to be completed in	Month		
		Year	19....	19.... 19....
10.	Project cost in reporting period Note: Include only direct costs. Operating costs include salaries, travel and expend- able equipment as typical items. Capital costs in- clude instruments and observ- ing platforms. Exclude capital depreciation costs and capital consumption allowances.	Operating \$ Thousands		
		Capital \$ Thousands		
		Total \$ Thousands		
11.	Enter sources of the funds (total of 10 above) by approximate percentage distribution	Federal		
		Provincial		
		University		
		Industry		
		Other Canadian		
		Specify		
		Foreign		
12.	Using reporting year costs as 100, estimate costs in preceding and following years. (For example, if total cost of this project was 101 less in 1982 than in 1983 and the project was completed in 1983, enter 99 for 1982 and 0 for 1984)	1982		
		1984		
13.	Attach a list of papers, reports and publications resulting from these projects, identifying each list by project title.			

REPORTING UNIT QUESTIONNAIRE

1. Institution or Agency Address

Include name and address of reporting unit, section or division.

2. Reporting Year

NOTE: The reporting period should be one year in length, either calendar year 1983, or where more convenient, the closest fiscal year (e.g., for federal agencies FY 1983-84).

From Month Year
To Month Year

3. Research Expenditures, by Water Resources Water resource research sub-category Code #

Year	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
No. of Projects			X	X	X
					(projected)

Group actual or forecast project costs according to sub-categories. For 1982 and 1983 enter also number of projects. If more than four sub-categories are reported, please use additional sheets.

If reasonable estimates of "overhead" costs for space, power, senior administration etc. are readily available, include these in operating costs: Insert H after the entry if overhead charges are included.

Exclude capital depreciation costs and capital consumption allowances.

See attached page for research sub-categories.

Year	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
Expenditures in thousands \$					
Operating					
Capital					
Total					

Year	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
No. of Projects			X	X	X
					(projected)

Year	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
Expenditures in thousands \$					
Operating					
Capital					
Total					

Year	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
No. of Projects			X	X	X
					(projected)

Year	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
Expenditures in thousands \$					
Operating					
Capital					
Total					

Year	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
No. of Projects			X	X	X
					(projected)

Year	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
Expenditures in thousands \$					
Operating					
Capital					
Total					

4. Sources of funds 1983

Enter percentage values (based on 1983 operating & capital = 100)

Canadian: Federal _____ Provincial _____
University _____ Industry _____

Other Canadian _____ (Specify.....)

Foreign _____

5. Professional Effort:

For reporting period.

For each relevant sub category of research, please list the discipline or professional background of the participants and enter the professional effort for the reporting period.

If additional space is required, please use additional sheet.

Sub-category
Code NumberDiscipline
or
Professional
Background

Doctor

Master

Bachelor

6. Additions to Professional Staff 1983-85

Enter the annual additions to required professional staff, by highest earned degrees.

If additional space is required, please use additional sheet.

1983-4-5 Additions to Professional Staff

Discipline

Doctor

Master

Bachelor

1983

1984

1985

1983

1984

1985

1983

1984

1985

7. Technician Effort in man years

By field of training
For 1983 enter actual values.
For 1984, 5 forecast the required annual addition.

Name of
Field or Trade

Man years (nearest unit)

1983

1984

1985

8. Nature of projects planned to begin in 1985

8.1 Title and/or one-line description
.....Sub-category of research code number.....

8.2 Title and/or one-line description
.....Sub-category of research code number.....

8.3 Title and/or one-line description
.....Sub-category of research code number.....

8.4 Title and/or one-line description
.....Sub-category of research code number.....

8.5 Title and/or one-line description
.....Sub-category of research code number.....

(Code from attached list)

We would appreciate receiving a copy of your annual report, if such is available.



Waterloo, Ontario, Canada
N2L 3G1

Faculty of Engineering
Department of Civil Engineering
519/885-1211

le 1^{er} août 1984

Le Conseil des Sciences du Canada et l'Enquête en vue d'une politique fédérale en matière d'eau sont les co-commanditaires de notre étude sur le statut de la recherche sur les ressources en eau au Canada. Une lettre confirmant cette commandite est annexée. Les objectifs de cette étude sont:

- (1) fournir une mise à jour de l'inventaire des activités de la recherche sur l'eau au Canada pour 1983 ou avril 1983-mars 1984, qu'importe laquelle est appropriée à votre organisation, en identifiant l'effort des différentes catégories de recherches parmi le fédéral, le provincial, l'université et les secteurs privés.
- (2) identifier les futurs besoins et priorités de recherches, et,
- (3) évaluer les programmes fédéraux en termes de leur capacité à répondre aux changements de priorités de la recherche sur les ressources en eau, leur coordination et leur gestion au Canada.

Les sources étant contactées pour cette information sont des individus et des organisations impliqués dans la recherche sur les ressources en eau partout au Canada.

Nous apprécierions que vous nous envoyez l'information au sujet de la recherche sur les ressources en eau de votre département.

Deux questionnaires sont inclus. Le questionnaire de l'unité de rapport est utilisé pour recueillir l'information sur le coût global et la main-d'œuvre. Le questionnaire sur le projet est utilisé pour recueillir l'information décrivant les projets de recherches individuels. Ces questionnaires devraient être distribués aux individus responsables des projets de recherches particulier.

Nous sommes au courant que Bruce et Maasland ont publié un rapport pour le Conseil des Sciences du Canada sur le statut des ressources en eau au Canada en 1968 et qu'en 1979 Environnement Canada avait mis à jour leur inventaire. Plusieurs personnes, partout au Canada, ont pris un temps considérable pour fournir les données essentielles de ces études. Notre devoir, en dirigeant cette troisième étude, implique la soumission d'un rapport au début de 1985, à la fois mettant à jour l'inventaire, et en identifiant les futures issues, opportunités, contraintes et stratégies relatives à la recherche sur les ressources en eau au Canada. Les résultats de cette enquête seront utilisés par l'Enquête en vue d'une politique fédérale en matière d'eau.

Bien que nous demandons les noms des chercheurs, cette information sera utilisée seulement pour faciliter la catégorisation et le traitement. Les réponses seront traitées confidentiellement et aucun individu ne sera identifié par son nom dans le rapport.

Pour que les réponses de votre département soit prise en compte totalement, nous avons besoin de recevoir le questionnaire complété au plus tard le 14 septembre 1984. En somme, nous espérons que vous les distribuez aussi vite que possible à vos chercheurs, et leur faire part de l'importance de recevoir leur commentaires.

Si vous avez des questions, s'il vous plaît, n'hésitez pas à nous contacter. S'il vous plaît, retourner votre correspondance à:

Professor Edward McBean
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario, N2L 3G1

Sincèrement

Sincèrement

Bruce Mitchell,
Professor of Geography
(519) 885-1211 (Ext. 3064)

Edward McBean,
Professor of Civil Engineering
(519) 885-1211 (Ext. 3349)



LE CONSEIL DES SCIENCES DU CANADA ET LA
COMMISSION D'ENQUÊTE SUR LA POLITIQUE FÉDÉRALE DE L'EAU

ENQUÊTE SUR LA RECHERCHE DANS LE DOMAINE DE L'EAU

Au cours des années 60, le Conseil des sciences du Canada a entrepris une étude importante relative aux recherches sur les ressources en eau, étude qui a donné lieu à la publication en 1968 de l'étude de documentation n° 5, effectuée par Bruce et Maasland et intitulée La recherche dans le domaine de l'eau au Canada, et du rapport du Conseil n° 3 intitulé Un programme majeur de recherches sur les ressources en eau du Canada. De nouvelles questions (la pollution causée par les produits chimiques toxiques, les transferts entre bassins) prennent de plus en plus d'importance et exigent une réévaluation des besoins en matière de recherche dans le domaine de l'eau d'ici l'an 2000. Il y a quelques années, Environnement Canada a organisé plusieurs ateliers en vue d'étudier quelques questions pertinentes, mais non l'orientation future des recherches dans le domaine de l'eau. Le Conseil des sciences envisage donc d'approfondir davantage la question.

Fort de l'autorisation du Cabinet, le ministre de l'Environnement a récemment établi une Commission d'enquête sur la politique fédérale de l'eau, formée de trois membres et présidée par le D^r Peter Pearce. La Commission d'enquête a pour mandat de se renseigner à fond auprès des Canadiens et de leurs gouvernements; d'établir la nature des nouvelles questions; d'évaluer la quantité d'eau actuellement disponible ainsi que les besoins futurs en ce qui touche la conservation et l'utilisation de l'eau, et "d'évaluer les besoins et la nature des compétences additionnelles nécessaires en sciences et en recherches dans le domaine de la gestion des ressources en eau au Canada".

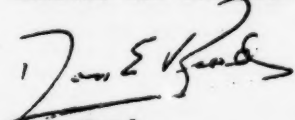
Vu leur intérêt commun à l'égard des futures activités de recherche dans le domaine de l'eau, la Commission d'enquête et le Conseil des sciences ont accepté de parrainer conjointement des travaux dans ce domaine et ont conclu un marché avec MM. Edward McBean et Bruce Mitchell, professeurs à l'Université de Waterloo, aux fins d'exécution du projet.

Ce projet mixte a pour but de :

1. Mettre à jour le répertoire des activités de recherche dans le domaine de l'eau à partir des rapports publiés en 1968 par le Conseil des sciences et du document publié en 1979 par Environnement Canada, déterminer les modifications apportées aux travaux exécutés dans les divers domaines de recherche ainsi que les modifications des travaux et du financement dans les secteurs fédéral, provinciaux, universitaires et privés.

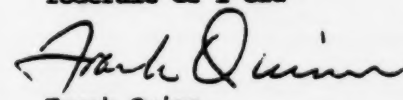
2. Déterminer les priorités et les besoins futurs en matière de recherche, en tenant compte des tendances actuelles et des nouvelles questions dans le domaine de l'eau, établies par la Commission d'enquête sur la politique fédérale.
3. Évaluer les programmes de recherche fédéraux en ce qui touche leur capacité de s'adapter aux priorités changeantes de la recherche, de la coordination et de la gestion des ressources en eau au Canada.

Conseil des sciences du Canada


D.E. Read
Conseiller scientifique

July 13, 1984

Commission d'enquête sur la politique
fédérale de l'eau


Frank Quinn
Directeur de la recherche

Questionnaire de l'unité de rapport

1. Institution ou agence Adresse

Inclure nom et adresse de l'unité de rapport, section ou division

2. Année rapportée De.....

NOTE: La période rapportée devrait être d'une durée d'un an, soit l'année du calendrier 1983, ou la fin de l'année fiscale, là où c'est plus pratique (e.g., pour les agences fédérales, l'année fiscale 1983-4)

3. Dépenses de recherche sur les ressources en eau par sous-catégorie de recherche pour chaque année 1982 - 1986. Recherche sur les ressources en eau sous-catégorie Code #

Année	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
Nombre de projets			X	X	X
(projet)					
Dépenses en milliers\$					
Fonctionnement					
Capital					
Total					

Si des estimations raisonnables des coûts de vos frais généraux (overhead) pour l'espace, l'énergie, l'administration supérieure, etc., sont facilement disponibles, inclure ceux-ci dans les coûts de fonctionnement. Inscrivez la lettre H à côté du chiffre si les frais généraux (overhead) sont inclus

Exclure les coûts de capital pour la dépréciation et les allocations de capital pour les fournitures.

Voir la feuille ci-jointe pour les sous-catégories de recherche.

Année	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
Nombre de projets			X	X	X
(projet)					
Dépenses en milliers\$					
Fonctionnement					
Capital					
Total					

Année	1982	1983	1984	1985	1986
	82/83	83/84	84/85	85/86	86/87
Nombre de projets			X	X	X
(projet)					
Dépenses en milliers\$					
Fonctionnement					
Capital					
Total					

4. Sources de fonds en 1983

Entrer les valeurs en pourcentage (basé sur la fonctionnement et le capital en 1983 = 100)

Canadien: Fédéral _____ Provincial _____
 Université _____ Industrie _____
 Autre source canadienne _____ (Spécifiez.....)
 Source étrangère _____

1983: Effort professionnel en homme par année (le plus rapproché de 1)

5. Effort professionnel: Pour la période rapportée
- | Numéro de code de la sous-catégorie | Discipline ou formation professionnelle | Doctorat | Maîtrise | Baccalauréat |
|-------------------------------------|---|----------|----------|--------------|
| | | | | |
| | | | | |
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| | | | | |
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| | | | | |
| | | | | |
| | | | | |
| | | | | |
- Four chaque sous-catégorie de recherche pertinente, s'il vous plaît, donner la discipline ou la formation professionnelle des participants et notifier l'effort professionnel pour la période rapportée.
- Si de l'espace additionnelle est requise, s'il vous plaît, utiliser une feuille supplémentaire.
6. Additions au personnel professionnel 1983-85
- | Discipline | Doctorat | | | Maîtrise | | | Baccalauréat | | |
|------------|----------|------|------|----------|------|------|--------------|------|------|
| | 1983 | 1984 | 1985 | 1983 | 1984 | 1985 | 1983 | 1984 | 1985 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
- Notifier les additions annuelles requises au personnel professionnel par les plus haut degrés gagnés.
7. Effort des techniciens en homme par année par champ de formation
- | Nom du champ ou métier | Homme par année (le plus près de l'unité) | | |
|------------------------|---|------|------|
| | 1983 | 1984 | 1985 |
| | | | |
| | | | |
| | | | |
| | | | |
- Pour 1983, inscrivez les valeurs actuelles.
- Pour 1984, 5, prévoyez l'addition annuelle requise.
8. Nature des projets prévus pour le début de 1985
- 8.1 Titre et/ou description en une ligne
.....Numéro de code de la sous-catégorie de recherche.....
- 8.2 Titre et/ou description en une ligne
.....Numéro de code de la sous-catégorie de recherche.....
- 8.3 Titre et/ou description en une ligne
.....Numéro de code de la sous-catégorie de recherche.....
- 8.4 Titre et/ou description en une ligne
.....Numéro de code de la sous-catégorie de recherche.....
- 8.5 Titre et/ou description en une ligne
.....Numéro de code de la sous-catégorie de recherche.....
(Code venant de la liste ci-jointe)

Nous apprécierions recevoir une copie de votre rapport annuel, si disponible.

QUESTIONNAIRE SUR LE PROJET

105

1. Institution ou agence
(Nom et adresse)
2. Année rapportée
Note: La période rapportée devrait être d'une durée de
d'un an, soit l'année du calendrier 1983, ou la fin de l'année fiscale, là où c'est plus pratique (e.g., pour les agences fédérales, l'année fiscale 1983-84).
Mois Année

Remarques sur le projet

Note: Les questions 3 à 13 ci-dessous doivent être répondues pour chaque projet actif de l'année rapportée. Cette feuille de retour fournie de l'espèce pour un maximum de trois projets. Pour des projets supplémentaires, utilisez soit des formulaires supplémentaires ou joindre des feuilles supplémentaires avec les numéros des questions et des réponses.

3. Titre du projet (vingt mots ou moins).....				
Breve description de l'objectif.....				
3. Titre du projet (vingt mots ou moins).....				
Breve description de l'objectif.....				
3. Titre du projet (vingt mots ou moins).....				
Breve description de l'objectif.....				
4. Sous-catégorie de recherche				
Note: Inscrivez les catégories les plus applicables de la liste ci-jointe				
5. Nom du directeur du projet	Nom			
	Prénoms			
6. Travail sur le projet mentionné dans l'année rapportée	Docteur			
	Maîtrise			
	Baccalauréat			
	Assistants sous-gradués et post-gradués			
	Techniciens			
7. Est-ce que le projet était sollicité par une autre agence? <u>Extrême</u>	Oui	Non	Oui	Non
8. Est-ce que le projet était en coopération avec une autre agence durant la période rapportée? Note: Un projet coopératif est un projet dans lequel 2 institutions ou agences, ou plus sont activement engagées dans la recherche, ou une deuxième institution fournit des instruments et des moyens techniques. Si une deuxième institution supporte simplement le projet financièrement, le projet ne devrait pas être considéré coopératif. <u>Extrême</u>	Oui	Non	Oui	Non
9. Durée du projet. Ce projet a débuté en	Mois			
	Année	19....	19....	19....
et est prévu être terminé en	Mois			
	Année	19....	19....	19....
10. Coût du projet dans la période rapportée. Note: Inclure uniquement les coûts directs. Les coûts de fonctionnement incluent les salaires, les voyages et l'entretien de l'équipement ou autres articles typiques. Les coûts de capital incluent les instruments et les plateformes observatoires. Inclure les coûts de capital pour la dépréciation et les allocations de capital pour les fournitures.	Fonctionnement \$ Millions			
	Capital \$ Millions			
	Total \$ Millions			
11. Inscrivez les sources de fonds (total de la question 10 ci-dessus) par le pourcentage approximatif de distribution.	Fédéral			
	Provincial			
	Université			
	Industrie			
	Autre sources canadiennes (Spécifier)			
	Sources étrangères			
12. En utilisant les coûts de l'année rapportée comme 100, estimez les coûts des années précédentes et suivantes. (Par exemple, si le coût total du projet était de 200 millions en 1982 qu'en 1983 et le projet était terminé en 1983, entrez 50 pour 1982 et 0 pour 1984).	1982			
	1984			
13. Annoncez une liste des articles, des rapports et des publications résultant de ces projets, en identifiant chaque liste par le titre du projet.				

EVALUATION DES BESOINS DE RECHERCHE

Comme avec tous les questionnaires, leur distribution doivent être limités. Cependant, des réponses obtenues, nous devons extrapoler l'information pour caractériser sur la scène nationale, la recherche sur les ressources en eau au Canada. Ceci n'est pas une tâche qui est simple, ni une tâche à prendre à la légère, dû aux dangers important d'omission et de duplication. Ainsi, quand vous complétez le questionnaire, s'il vous plait garder en mémoire:

- (i) la responsabilité de la recherche que vous reportez est pour:
e.g. (a) vous comme un individu
(b) la section, division ou unité dans laquelle vous travaillez
(c) autre (spécifiez)
- (ii) le questionnaire étant complété par un groupe de personnes avec différentes formations, cette manière impliquant quelques questions pouvant être plus directement applicable à vous qu'à d'autres.
1. Selon vous, quels sont les besoins et les priorités en matière de recherche sur les ressources en eau au Canada présentement et d'ici l'an 2000? Quelles issues sont probablement les plus importantes dans les années 1990 et que devrions nous faire en recherche maintenant afin d'être prêt à faire face à ces issues dans les années 1990?
2. Quels changements devrions nous faire pour améliorer la capacité des programmes de recherche fédéraux afin de répondre aux priorités de changements pour la recherche sur les ressources en eau?
3. Quels changements devrions nous faire pour améliorer la coordination des programmes fédéraux de recherche sur les ressources en eau apparenté aux différentes activités de recherche parmi les différents départements fédéraux ainsi que les gouvernements provinciaux, les universités et le secteur privé?
4. Est-ce que les résultats de la recherche sur les eaux au Canada sont effectivement appliqués à la résolution de problèmes pratique? Si non, quels sont les obstacles principaux à leur application? Que devrions nous faire pour améliorer l'utilisation des résultats de recherche sur les eaux dans les années 1990 afin de résoudre des problèmes pratiques?
5. Dans la planification et la direction de la recherche sur les ressources en eau, quelle proportion de votre temps de recherche en 1983 ou 83/84 a été alloué aux catégories suivantes?

	Mission Orientée	Sans contrainte par mission ou mandat
Recherche pure et fondamentale		
Recherche appliquée		

Selon votre estimation, quel serait un effort mixte approprié à un niveau national durant les années 1990?

	Mission Orientée	Sans contrainte par mission ou mandat
Recherche pure et fondamentale		
Recherche appliquée		
		100

Commentaires:

6. Les problèmes de l'eau croisent des frontières disciplinaires et professionnelles, encore que la structure de la plupart des agences gouvernementales et des universités apaise souvent l'autre recherche interdisciplinaire ou l'intégration des résultats de recherche de différentes activités.
 - (a) Quel pourcentage de votre travail de recherche a été fait dans un travail d'équipe? _____
 - (b) Quand vous avez été impliqué dans un groupe de recherche est-ce que les autres individus avaient une formation disciplinaire ou professionnelle similaire à la votre? _____
 - (c) Quel action le gouvernement fédéral pourrait-il prendre pour encourager encore plus, dans le futur, la recherche interdisciplinaire?
7. Dans un pays aussi vaste et diversifié que le Canada, les issues régionales de ressources en eau peuvent être bien différentes. Quel action pourrait bien prendre le fédéral pour assurer que les programmes de recherches sur les ressources en eau répondent, dans le futur, plus efficacement aux différents besoins régionaux?
8. Quelles sont les contraintes majeures - manque de fonds, votre temps, manque de personnel professionnel, manque de techniciens, espace inadéquat, équipement inadéquat ou autre (?) - qui jouent un vaste rôle dans la recherche sur les ressources en eau dans votre organisation? S'il vous plaît indiquer les priorités et commenter brièvement.
9. Si votre travail a résulté en publications, quel pourcentage a été publié dans des journaux canadiens? Quelles sont les raisons de vos décisions de publier dans des journaux autre que canadiens, quand ils existent? Quels changements sont nécessaires pour vous encourager de publier plus, dans le futur, dans des journaux canadiens?
10. Dans votre propre recherche, quand vous considérez le rôle du gouvernement fédéral dans la recherche en eau au Canada, quels sont les issues les plus importantes et les besoins demandant une attention dans les prochaines années? S'il vous plaît, indiquer les priorités.

Quels issues et besoins recevant une attention considérable durant la dernière décade pourrait, selon votre estimation, recevoir une attention moindre dans les 2 prochaines décades?

Autres commentaires/suggestions:

Les questions suivantes sont destinées aux personnes en relation avec l'université, bien que nous souhaitons les commentaires de tous autres partis intéressés.

1. Est-ce que les professeurs devraient avoir la permission d'acheter à l'extérieur (buy out) une partie de leur tâche d'enseignement (où une partie de l'argent de recherche est utilisé pour engager d'autres individus pour assumer une partie (mais pas en totalité) des responsabilités d'enseignement?)

2. Combien de propositions de recherche avez vous écrit et, de ceux-ci, combien ont été consolidé durant la période rapportée? Quelle était la raison majeure pour laquelle vous avez préparé le nombre que vous avez rapporté et pas plus?

3. Si vous avez un centre désigné pour la recherche sur les ressources en eau à votre université, s'il vous plaît, fournir:
 - (a) son nom: _____
 - (b) la date à laquelle il a été établi: _____
 - (c) sujets/champs d'activités de la recherche sur les ressources en eau dans lequel il est spécialisé: _____
 - (d) le nombre d'employés en 1983
 - (e) le statut (est-ce que le centre a une entité formelle?)

4. De quelles sources avez vous reçu vos fonds pour supporter vos étudiants gradués (ceci n'inclus pas les boursiers et les individus supportés par eux-mêmes) travaillant dans le champ de la recherche sur les ressources en eau?

CRSNGC	CRSHC	CNR	SCHL	ENV. CANADA DGEI	FEDERAL AUTRE (SPECIFIEZ)	PROVINCIAL (SPECIFIEZ)	SECTEUR PRIVE (SPECIFIEZ)	AUTRE
_____	_____	_____	_____	_____	_____	_____	_____	_____

_____ TOTAL
= 100%

Vos efforts en vue de compléter le questionnaire sont grandement appréciés.

S'il vous plaît, retourner vos questionnaires complétés à:

Professor Edward McBean
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario, N2L 3G1

APPENDIX II

ATTENDEES AT THE WORKSHOP

APPENDIX II

Listed below are the participants involved in the workshop held in Kitchener in November 1984. Indicated also are the individual's affiliation as of the workshop dated.

P. Ashton	Intergroup Consulting Economists Ltd. Winnipeg
B. Ayles	Freshwater Institute Fisheries and Oceans Winnipeg
R.D. Bailey	Water Resources Division Department of Indian & Northern Affairs Ottawa
W.F. Cardy	Water Resources Branch Environment New Brunswick Fredericton
A.H.J. Dorcey	Westwater Research Centre University of British Columbia Vancouver
M. Gilbertson	Fish Habitat Management Branch Ottawa
D.H. Lennox	National Hydrology Research Institute Environment Canada Ottawa
F. Quinn	Inquiry on Federal Water Policy Ottawa
D. Read	Science Council of Canada Ottawa
H. Regier	Institute for Environmental Sciences University of Toronto Toronto
G.K. Rodgers	National Water Research Institute Environment Canada Burlington
M. Slivitsky	INRS - Eau Ste-Foy, P.Q.
G.C. Topp	Land Resource Research Institute Agriculture Canada Ottawa

J. Whiting	Saskatchewan Research Council Saskatoon
S.O. Winthrop	Environmental Health Directorate Health and Welfare Canada Ottawa
B. Mitchell (Convener)	Department of Geography University of Waterloo Waterloo
E. McBean (Convener)	Department of Civil Engineering University of Waterloo Waterloo